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THE INTERNATIONAL CELESTIAL REFERENCE FRAME AS REALIZED BY VERY LONG BASELINE INTERFEROMETRY

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ABSTRACT

A quasi-inertial reference frame is defined based on the radio positions of 212 extragalactic sources distributed over the entire sky. The positional accuracy of these sources is better than about 1 mas in both coordinates. The radio positions are based upon a general solution for all applicable dual-frequency 2.3 and 8.4 GHz Mark III very long baseline interferometry data available through the middle of 1995, consisting of 1.6 million pairs of group delay and phase delay rate observations. Positions and details are also given for an additional 396 objects that either need further observation or are currently unsuitable for the definition of a high-accuracy reference frame. The final orientation of the frame axes has been obtained by a rotation of the positions into the system of the International Celestial Reference System and is consistent with the FK5 J2000.0 optical system, within the limits of the link accuracy. The resulting International Celestial Reference Frame has been adopted by the International Astronomical Union as the fundamental celestial reference frame, replacing the FK5 optical frame as of 1998 January 1.

Key words: astrometry — catalogs — quasars: general — radio continuum — reference systems — techniques: interferometric

1. INTRODUCTION

Celestial reference frames have been used for millennia for purposes of measuring the passage of time, for navigation, and for studying the dynamics of the solar system. In the last century, these frames have become more important to both the study of the dynamics of more distant objects and the study of geophysical phenomena on Earth. Using optical telescopes, reference frames with roughly 0".1 accuracy were produced. With the advent of the technique of very long baseline interferometry (VLBI), rapid improvements in positional accuracy became possible, reaching the milliarcsecond level in the late 1980s. By the mid-1990s, the VLBI technique had improved to such a level that submilliarcsecond positional accuracy became possible. The consequent increase in the level of accuracy of celestial reference frames has permitted unprecedented studies of celestial dynamics and geophysical phenomena.

A stellar reference frame is time dependent because stars exhibit detectable motions. For precise astrometric applications, a stellar frame must specify, in addition to positions, an epoch and predicted stellar motions. Imprecise knowledge of proper motion and/or parallax limits the precision of stellar frames at epochs other than the mean epoch of the catalogs. Extragalactic radio sources, on the other hand, are assumed to be very distant (typical redshifts of about 1.0) and thus should exhibit little or no detectable motion. A reference frame defined by the positions of extragalactic radio sources may be said to be a quasi-inertial frame (i.e., a frame nonrotating with respect to an inertial frame) with little or no time dependency.

There exists a large resource of high-accuracy, dual-frequency bandwidth synthesis VLBI data that were acquired from various networks for geodetic and astrometric purposes over a span of more than 15 years and from which various radio source catalogs have been constructed. The goal of the work described here was to create the definitive catalog of extragalactic radio source positions for the International Celestial Reference Frame (ICRF), using the best data and methods available at the time the work was done. This work was the joint cooperative effort of a subgroup of the International Astronomical Union (IAU) Working Group on Reference Frames (WGRF), which was formed expressly for this purpose. Background material on

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the contribution of VLBI to astrometry and geodesy, a bibliography of previous work, and ancillary information on ICRF sources can be found in Ma & Feissel (1997).

Having gained experience from past efforts, the subgroup has taken an empirical approach in the selection of data, analysis, estimation of errors, and categorization of the final results. The characterization of a radio source, i.e., its position, how it was treated in the analysis, and whether it was suitable for use as a defining object, was derived entirely from the VLBI data and analysis, and not from any other information. This approach leads to a rigorous selection of defining objects and a reliable realization of the ICRF as a set of relative positions oriented to the axes of the International Celestial Reference System (ICRS; Arias et al. 1995). In the context used here, *defining* refers to those sources with accurate, reliable positions that could be used to orient the ICRF axes.

Several points should be noted at the outset. This realization of the ICRF was considered only one of many, both actual and potential, better than preceding ones, but by no means attaining perfection. The source positions and their characteristics are derived from a particular, although comprehensive, set of data using specific frequencies and networks of stations and covering a certain interval of time. The underlying physics of the target extragalactic radio sources (Marscher 1987) is not as well understood as that of stars, and we can only describe with certainty what the radio sources did during the particular interval of time covered by the observations. It is clear that many extragalactic objects undergo changes in intrinsic structure that can affect their realized positions at levels greater than the precision of their position estimates. From the data set we can see what has happened in the past and surmise, but not predict theoretically, what can be expected in the future. Although extragalactic objects are not as predictable as stars, the benefit of extragalactic objects and VLBI radio astrometry is that the level of astrometric uncertainty is at least 1 order of magnitude better than when using optical measurements of stars. The potential weakness is that the quality of the ICRF so derived cannot easily be given a purely theoretical underpinning.

Because the vast majority of observations were made for geodetic purposes and therefore used the brightest compact radio sources, while the strictly astrometric observations constitute only a small fraction of the total, the information available on the sources from the VLBI data varies enormously. The approach we have taken is to derive the measure of ideal behavior, i.e., invariant position in the celestial frame, from the available data. In some cases, thousands of observations lead to the discovery of statistically significant position variations. For other sources we might only be able to say that the variations in position are not inconsistent with their measurement uncertainties. Fortunately, there is a sufficiently large class of radio sources with more than enough observations and minimal position variations to make the effort worthwhile. In addition, comparisons between independently derived catalogs were used as a consistency check. When significant discrepancies were discovered in such comparisons, the particular sources in question were considered less reliable for use in the ICRF. It was not possible, given the number of observations, to try to explain the small number of discrepant positions.

It was considered essential that the realization of the ICRF be derived from a single analysis, even if imperfect, rather than from a combination catalog made of sever[al] VLBI solutions. While various recent catalogs are n[ot] inconsistent, except for a few discrepant sources, a com[bination] catalog loses certain information. The operation[al] realization of the ICRF is a set of right ascensions an[d] declinations, but the actual information is the much larg[er] set of relative positions, whose quality is contained in th[e] full covariance matrix. A typical combination catalog doe[s] not give access to this information. In addition, there i[s] extensive but not complete overlap of data used in some o[f] the VLBI analyses, and there are differences in modelin[g] between analysis groups. Consequently, understanding th[e] statistics and systematic errors of a combination solution i[s] not straightforward.

2. DATA

VLBI observations for geodesy and astrometry usin[g] Mark III–compatible systems (Clark et al. 1985) have bee[n] conducted since about mid-1979. These observations ar[e] made in a bandwidth synthesis mode at standard frequencies of 2.3 GHz (S band) and 8.4 GHz (X band). Dual-frequency observations allow for an accurate calibration of the frequency-dependent propagation delay introduced by the ionosphere, while the multiplicity of channels within a band facilitates the determination of a precise group delay (Rogers 1970). A phase calibration signal is injected into the receiver at both bands at most stations to remove instrumental dispersion and time variations in instrumental delay. Meteorologic information is logged at most stations and is used in tropospheric modeling. Observing sessions are typically of 24 hours' duration, as this period of time is required to recover (separate) parameters for nutation and polar motion.

The VLBI observations used for the ICRF have been obtained primarily by the NASA Crustal Dynamics Project (CDP), now succeeded by the Space Geodesy Project, the Jet Propulsion Laboratory (JPL), which is operated by the California Institute of Technology for NASA, the Geosciences Laboratory (GL), formerly part of the National Geodetic Survey (NGS), which is operated by the National Oceanographic and Atmospheric Administration (NOAA), the US Naval Observatory (USNO), and the US Naval Research Laboratory (NRL).

The CDP programs included several long-term monitoring projects, such as the program to monitor motions between the North American and Pacific plates. In addition, there are numerous short-term projects, too many and too specialized to describe here. The interested reader is referred to Ryan, Ma, & Caprette (1993b). The JPL observations were made primarily for purposes of spacecraft navigation using the Deep Space Network telescopes. Information on aspects of the JPL program can be found in Sovers (1990) and Jacobs & Sovers (1993). Additional information on the GL/NGS observing programs can be found in Robertson et al. (1985, 1993). Information on the USNO Earth orientation observing program can be found in McCarthy & Luzum (1991). The NRL program is described by Johnston et al. (1995).

The geodetic/astrometric VLBI data set has a rich variety of stations and networks. Antennas range from 3 to 100 m in diameter. Baselines range from a few tens of meters to nearly the diameter of Earth. Although extreme baselines contributed very little to the total number of observations and smaller mobile antennas lacked sensitivity to see any but the brightest sources, the entire data set was used (except for sessions entirely between antennas at a single observatory), pooled cooperatively from all the various observing programs. Besides providing the potential for extracting the maximum information, the use of the entire data set includes the widest variation that the network geometry and station size can impose upon the realized ICRF. The ICRF positions and stated uncertainties should then represent realistically how confidently the positions can be used in the future with arbitrary VLBI measurements. The VLBI data for this work were edited following the usual procedures of each contributing group. In the context used here, one observation represents one group delay–phase delay rate pair.

3. ANALYSIS SOFTWARE

While the subgroup had access to several analysis systems and data sets, the solution for the ICRF was made at Goddard Space Flight Center (GSFC) largely for two reasons, one of convenience and one for better modeling. The GSFC system had access to more data and had already implemented an improved tropospheric model. Similar results could have been obtained at other analysis centers such as JPL, but with greater effort. Detailed comparison of the GSFC and the JPL software, described in more detail in § 7.2, gives confidence in the correctness of the mechanical implementation of the VLBI modeling.

The GSFC analysis system (Ryan, Ma, & Vandenberg 1980; Ma et al. 1986; Caprette, Ma, & Ryan 1990; Ryan et al. 1993b) consists of the astrometric and geodetic VLBI reduction software CALC, SOLVE, and GLOBL. The data analysis methods using the GSFC system are covered in detail by Ma et al. (1986) and will be described only briefly here. CALC calculates the observation equations including most partial derivatives and contains most of the physical models of the reduction process, generally following the International Earth Rotation Service (IERS) Standards and Conventions (McCarthy 1992, 1996). The IAU definitions of precession (Lieske et al. 1977), sidereal time (Aoki et al. 1982), and nutation (Wahr 1981; Seidelmann 1982) were adopted as the underlying models. SOLVE uses the output of CALC, along with some additional modeling, to perform a least-squares solution to estimate parameters such as source or station positions and Earth orientation parameters. GLOBL is a noninteractive way of running SOLVE so that data from different experiments can be combined, allowing some parameters (e.g., source positions) to be estimated from a combination of many data sets. To obtain a solution, the individual data sets are combined sequentially using "arc" parameter elimination (Ma et al. 1990). All solutions give weighted least-squares estimates for parameters. Time-invariant or "global" parameters, i.e., parameters dependent on all data sets, are carried from step to step, resulting in a single estimate derived from the combined data of all experiments in the solution. Depending on the problem at hand, these global parameters may include station positions, station velocities, source positions, source velocities (proper motions), nutation series coefficients, the precession constant, Love numbers for the solid Earth tides, and the relativistic gamma factor. Local or "arc" parameters depend only on the data from an individual experiment and are estimated separately for each epoch of observation. Arc parameters include those for the station clocks and atmospheres, Earth's orientation, and nutation offsets in obliquity and longitude. Station positions an source positions can also be arc parameters if the solution to follow changes over time.

The astrometric positions given in this paper result fro a particular choice of analysis configuration as described i following sections.

4. PREPARATION FOR ANALYSIS

As suggested previously, the observed sources can b characterized along several lines. The most important ar variations in position seen in the data and the number c observations per source. The underlying conceptual basis c this type of realization of the celestial reference frame is tha positions are invariant with time. Therefore, the first tasl was to ensure that this condition was not significantly vio lated. A series of solutions was made. In each solution, th positions of all sources except for a small test set were esti mated as time-invariant "global" parameters. The posi tions of the test sources were treated as "arc" parameters with a position estimated for each day the source wa observed. Each source was treated as a test source in some solution. The complete set of source positions as functions of time was then analyzed to determine which sources had statistically significant variations in their positions. Sources were rejected if the magnitude of the weighted rms of the source position variations from one epoch to the next exceeded 0.5 mas or 3 σ (based on the position formal errors). In addition, in another solution proper motion was estimated as a "global" parameter for all sources with sufficient data (two or more observing sessions). For sources with sufficient data to derive statistically significant apparent linear motions, a source was considered problematic if the apparent motion exceeded 50 μas yr^{-1} and was greater than 3 times the formal error. Since these two classes of sources showed undesirably large position variation, they were treated differently from other sources in the final analysis. To accommodate their position variations without deforming the geometry of the remaining sources, the positions of these sources were adjusted separately for each session in which they were observed. A total of 102 of 608 observed sources were found to have unstable positions by these criteria.

5. CONFIGURATION OF THE ICRF ANALYSIS

The configuration of the ICRF analysis was developed as a balance between competing goals: the most data and the least systematic error; the best models and available options; the largest number of useful estimated parameters and computer speed, etc. As improvements occur in the future, the balance may shift and the results should be better still.

The most important configuration choices are related to data selection and modeling. To extract the most information from the data, both the group delay and phase delay rate observables were used. Only observations above 6° elevation were included in the solution, because of inadequacies in modeling the troposphere at lower elevations. There may also have been additional systematic error introduced into the solution because of poor modeling of phase delay rate variations induced by tropospheric fluctuations. The troposphere was modeled using the MTT mapping function (Herring 1992), estimating the zenith troposphere effects in the form of 1 hr piecewise linear continuous functions with constraints on the size of variations. While shorter time intervals have been shown to produce better geodetic results, they were not used in this analysis because of computer speed limitations. Time-variable gradients in the troposphere were also estimated (see § 6.3). The effect of tropospheric gradients on the source coordinates is described in § 7.3. Because it was not available in the GSFC analysis system, no atmospheric structure information (Treuhaft & Lanyi 1987) was used to weight the least-squares fit.

The primary geodetic parameters, the station positions, were estimated separately for each session. In this way, any nonlinear motion of the stations (e.g., unmodeled tectonic motion, long-term antenna motion, or earthquake displacements) does not affect the integrity of the invariant source positions. The relative source positions derived from a single 24 hr session are not distorted by forcing the station positions for that day to conform exactly to a linear model. Station motions within a day, from solid Earth tides and ocean loading, were derived from unadjusted a priori models (McCarthy 1992).

The weighting of the data followed the usual GSFC practice. For each session, a pair of added noise values was computed for delays and delay rates that caused the reduced χ_ν^2 (the χ^2 per degree of freedom) to be close to unity when added to the variance of the observations derived from the correlation and fringe-finding process, as well as the calibration of the ionosphere. Other modifications of the observational errors such as elevation-dependent and source-dependent noise were not used.

The unadjusted a priori models for geophysical effects, precession, and nutation generally followed the IERS Standards (1992) (McCarthy 1992). The VLBI theoretical model for the geometric portion of the delay (including relativistic effects) was the so-called consensus model given in the IERS Conventions (1996) (McCarthy 1996).

As mentioned previously, parameters were estimated using arc-parameter elimination (Ma et al. 1990), which is an incremental least-squares method that can accommodate large numbers of parameters if they are associated only with particular data intervals, or "arcs." In the ICRF analysis, several classes of parameters were adjusted. For each observing session, the adjusted arc parameters included positions of sources with identified excessive apparent motion or random variation; two celestial pole offsets to account for errors in the standard precession/nutation models; positions of the stations; the rate of UT1 relative to a good a priori time series; 1 hr troposphere parameters, described above; tropospheric gradients in the east-west and north-south directions, linear in time; quadratic clock polynomials for the gross clock behavior; 1 hr clock parameters similar to the 1 hr troposphere parameters; and necessary nuisance parameters, such as clock jumps and baseline clock offsets (i.e., separate bias parameters for each VLBI baseline to accommodate small, constant, baseline-dependent instrumental and correlator errors).

The remaining parameters were adjusted as invariant quantities from the entire data set. These "global" parameters included invariant source positions, geometric axis offsets for all fixed antennas, and 252 parameters for Earth rotation variations in the diurnal and semidiurnal bands caused by ocean tides.

The axis offset and ocean tide Earth rotation adjustments were all small and consistent with geodetic solutions, but the estimates were included to eliminate any influence o the source positions and to avoid falsely optimistic sourc position covariances that would occur if the axis offsets an tide parameters were assumed to be perfectly known.

After completing a series of test solutions to refin various aspects of the analysis, a final solution was run i the fall of 1995 that included 1.6 million pairs of grou delays and phase delay rates obtained from observation spanning the time period from 1979 August through 199 July. The postfit weighted rms residuals were 32.6 ps fo delay and 104.2 fs s^{-1} for rate, with a reduced χ_ν^2 of 1.0 There were 1305 global parameters, about 650,000 ar parameters, and over 2.5 million degrees of freedom.

Several results are obtained from the final least-square solution, designated "WGRF" for the following dis cussions. Of primary importance is the set of invarian source positions and their formal uncertainties. The ful covariance matrix of these source positions is anothe important result, although rather massive for everyday use The time series of positions for "arc" sources from the individual session estimates show the level and character o their position variations. For these sources, an additiona step was taken to calculate the weighted mean positions and weighted rms scatter as a measure of error. In addition the observation and session counts for each source give some indication of the usefulness of a source.

6. RELEVANT ESTIMATED AUXILIARY PARAMETERS

Some of the auxiliary model parameters that were determined in the course of generating the celestial reference frame are of interest for their own sake. Two sets of such parameters fall into categories that are related to the ICRF orientation and stability. The session-by-session nutation angle offsets from the a priori precession and nutation models in ecliptic longitude, $\Delta\psi$, and obliquity, $\Delta\epsilon$, contain information concerning inadequacies of the present IAU models of precession and nutation, and they thereby fix the orientation of the principal axis of the ICRS at J2000.0. This is found to be substantially different from the location of the standard IAU celestial pole at J2000.0.

Likewise, the positions of "arc" sources can be used as indicators of the time variability of their intrinsic structure. In addition to serving as indicators of the suitability of a source as a defining fiducial point in the ICRF, the time dependence of such source positions places limits on the stability of the frame over decadal time spans.

A third set of parameters of interest are those for modeling tropospheric delay gradients at the observing stations. The solution giving rise to the ICRF catalog is one of the first large-scale estimates of such gradients. As discussed in § 7.3, accounting for these gradients is essential in removing sizable declination systematic errors.

The following three subsections consider the above parameter categories in turn. Conditions of their estimation in the ICRF solutions are discussed in some detail, as is their relevance to the accuracy and stability of the ICRF on the one hand and astrometric/geodetic modeling on the other.

6.1. *Nutation and Precession Corrections and the Orientation of the Pole*

In order to achieve the best accuracy in the VLBI analysis leading to the ICRF, short-term variations of the celestial ephemeris pole need to be taken into account. As mentioned above, this was achieved by estimating corrections to the nutations in longitude, $\Delta\psi$, and obliquity, $\Delta\epsilon$, for each VLBI observing session. The time series of these estimated nutation angles are thus an integral part of the modeling for the ICRF. To preserve the highest accuracy, e.g., in calculating source coordinates of date, these corrections should be part of the model. Rather than interpolating this nonuniform time series, it is more convenient to generate corrections to the IAU a priori precession and nutation models by a least-squares fit to the series of nutation angles.

Figure 1 shows the time series of nutation corrections relative to the 1980 IAU model. Each point is plotted with its formal uncertainty from the VLBI solution giving rise to the ICRF source catalog. The curves show analytic functions fitted to the VLBI results in a postprocessing step. Approximately 2400 pairs of nutation angle corrections were fitted to a model that includes a bias, linear drift, and terms both in and out of phase with the 1980 IAU 18 yr, 9 yr, annual, semiannual, 121 day, and 14 day nutation terms. Points with formal errors that exceed 5 mas were omitted from the plot in order to provide an uncluttered graphic presentation. The omitted points amount to about 5% of the available points and do not affect the results significantly, because of their low weights. The resulting time rates of longitude (lunisolar precession) and obliquity are -2.84 ± 0.04 and -0.33 ± 0.02 mas yr^{-1}, respectively. These values are in reasonable agreement with recer published results (e.g., Charlot et al. 1995). Nutation ampl tudes of components in phase with the basic 1980 IA series are likewise in reasonable agreement with previo results: 18 yr (ψ, ϵ) in milliarcseconds ($-6.1 \pm 0.$ 2.7 ± 0.1), 9 yr (0.9 ± 0.04, -0.2 ± 0.02), annual (5.1 ± 0.0 2.2 ± 0.01), semiannual (1.6, -0.6), and 14 day (-0.3, 0.2 The formal uncertainties of the corrections for the last tw periods are all 0.01 mas, while the 121 day corrections ar not significant at the 0.1 mas level.

The reduced χ^2_ν value of 3.2 and the scatter about the fi are roughly consistent with the inflation of ICRF sourc coordinate formal uncertainties, discussed in § 9. Althoug the ICRS was constructed to be consistent with the FK pole of J2000.0, Figure 1 clearly shows that there is a differ ence between the mean J2000.0 pole and the ICRF pole o ≈ 19 mas in $\Delta\psi$ sin ϵ and ≈ 4 mas in $\Delta\epsilon$. However, thi difference is within the error of the stellar realization.

6.2. *Time Variation of Source Coordinates*

Some idea of the long-term stability of the ICRF can b gained from a consideration of test solutions in which th position of each source with sufficient data is allowed t vary linearly, subject to a global constraint of no net rotation. These solutions thus provide absolute proper motion relative to the entire ensemble of ICRF sources. Figure 2 shows the smoothed time evolution of the astrometric posi-

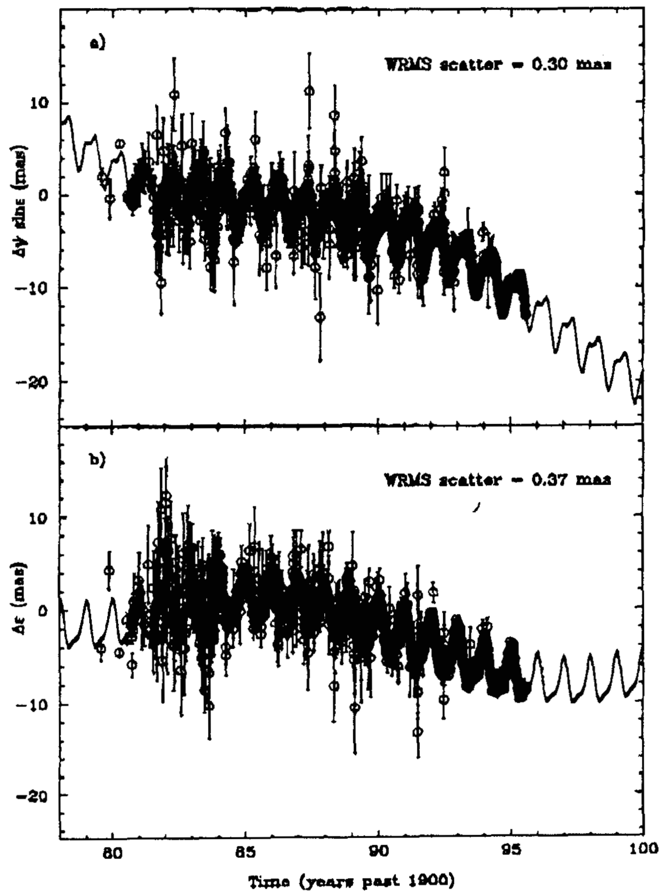

FIG. 1.—Time series of nutation corrections relative to the 1980 IAU model for (*a*) $\Delta\psi$ sin ϵ and (*b*) $\Delta\epsilon$ generated from the VLBI solution giving rise to the ICRF source catalog.

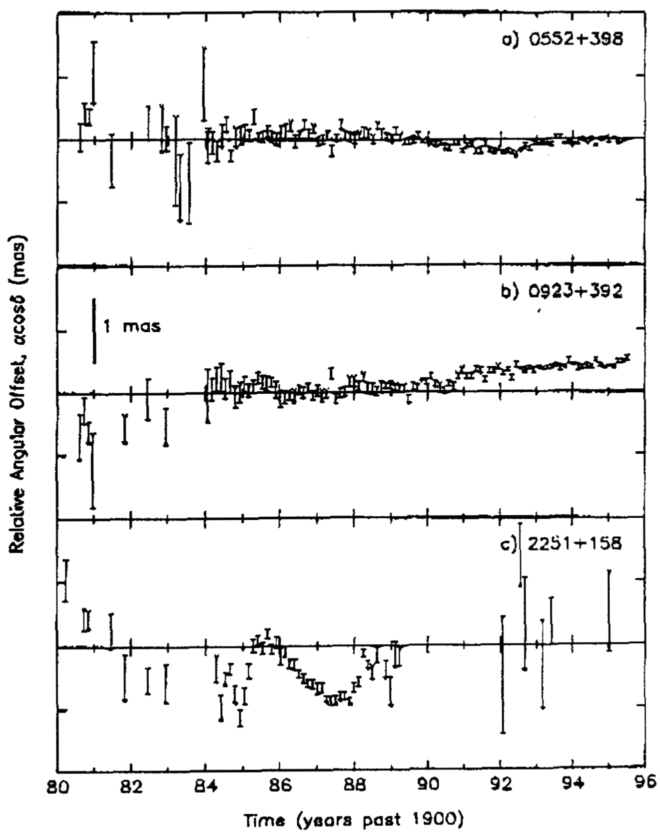

FIG. 2.—Time evolution of the astrometric position in α cos δ for the extragalactic sources (*a*) 0552+398 (DA 193), (*b*) 0923+392 (4C 39.25), and (*c*) 2251+158 (3C 454.3). Tick marks on the vertical axis are spaced 1 mas apart.

tions in $\alpha \cos \delta$ for three well-observed sources of different astrometric quality. The plotted positions represent 45 day moving averages, with no overlap, of the raw "arc" positions for these sources. The data have been averaged for clarity of presentation.

Figure 2*a* shows the time evolution of the right ascension of 0552+398 (DA 193), the most frequently observed source in the ICRF. A weighted least-squares fit to the data suggests that there is no statistically significant, long-term linear motion in the right ascension of this source. Figure 2*b* shows the time evolution of the right ascension of 0923+392 (4C 39.25). A weighted least-squares fit shows that, for this source, there is a statistically significant long-term motion. This motion is not seen in other angularly nearby ICRF sources, and it is interpreted as a change in the brightness distribution of this particular source. The observed angular rate of 59.8 ± 2.2 μas yr^{-1} for 0923+392 translates into an apparent transverse velocity of ~ 1.3 times the speed of light, strong evidence that this motion is due to intrinsic source structure changes (Fey, Eubanks, & Kingham 1997). The positions of both 0552+398 and 0923+392 have weighted rms residual scatters of about 0.2–0.3 mas about the best-fit linear model, indicating that the short-term stability of the ICRF is at approximately the 0.3 mas level, or better.

Figure 2*c* shows the time evolution of the right ascension of 2251+158 (3C 454.3). The data for this source are not well represented by any linear trend over periods much longer than a few months. The scatter of the residuals of the right ascension data about a straight-line fit is very much larger than can be explained by the formal errors. Clearly, the position of this source cannot be repeated to much better than about 1 mas, which indicates the limitations involved in using the positions of such sources as fiducial marks.

6.3. *Tropospheric Delay Modeling and Azimuthal Gradients*

Tropospheric propagation delay, which has been and continues to be one of the principal errors encountered in the analysis of VLBI astrometric and geodetic data, varies as a function of elevation and azimuth of the VLBI observation. Continuing improvements in the mapping functions that describe the elevation dependence of the tropospheric delay (Davis et al. 1985; Herring 1992; Niell 1996) have been successful in reducing systematic and random errors in estimated geodetic and astrometric parameters. In test solutions for the current work, no significant differences were found between the astrometric results using the MTT (Herring 1992) and the Niell (Niell 1996) mapping functions. Azimuthal asymmetries in the tropospheric delay, i.e., tropospheric gradients (Chen & Herring 1997), have been observed (Davis et al. 1993), and geodetic precision is improved when gradient parameters are estimated in the VLBI analysis (Herring 1992; MacMillan 1995). The systematic effect of tropospheric gradients on source positions is described in § 7.3. The estimated gradient parameters show a mean north-south asymmetry in the troposphere, as well as seasonal variations that depend on specific stations. Spatial variation in east-west gradients is about one-third the spatial variation in north-south gradients, while long-term mean east-west gradients are close to zero. The mean north-south gradient values are latitude dependent and are consistent with the general increase of pressure, temperature, water vapor, and tropopause height toward the equator. The nearly zero mean east-west gradient values are consistent with the general east-west progression of large scale weather systems.

7. SOURCES OF ERROR

Given the very large number of observations for some sources, the error contribution from observational noise is very small and not a meaningful measure of uncertainty. It is therefore necessary to consider several other effects in order to assign realistic errors. One consideration is the statistical validity of the formal errors. Another is the cumulative influence of all modeling errors and editing decisions. Yet another is the magnitude of specific, identifiable systematic errors that could have distorted the results.

7.1. *Statistical Validity of the Formal Errors*

The VLBI data used here have also been analyzed for geodetic purposes. Extensive tests of the geodetic results (Ryan et al. 1993a) indicate that a multiplicative factor of 1.5 is appropriate to scale the formal errors of estimated parameters, such as station positions, in order to represent their actual variation over subsets of data. Because of the relative paucity of data for many sources and the large amount of computer time required, a similar analysis was not undertaken for the astrometric results. Nonetheless, preliminary work shows that it is necessary to apply a similar scaling factor to the formal errors of the source positions. It should be noted that this scaling of formal errors is not intended to represent the degradation of source position repeatability in those sources with variable intrinsic structure. We have attempted to handle intrinsic-structure effects by stringently removing such sources from the defining list.

7.2. *Modeling Errors and Data Editing*

The cumulative effect of modeling errors and data editing can be examined in detail by comparison of radio source catalogs derived from independent analyses using different data and/or different analysis software. Intercomparison of different radio source catalogs addresses the problem of incorrect modeling and consequent systematic errors. Aspects that can be probed by catalog comparisons include (1) agreement between independent data sets, (2) processing differences at different analysis centers, (3) agreement between subsets of the same database, and (4) intentional perturbations of the modeling.

We have made a number of such comparisons between the WGRF catalog that was derived from all available VLBI data, associated catalogs derived from the same database that were created for test purposes, and existing radio source catalogs. Existing catalogs include the 1994 and 1995 IERS realizations of the celestial reference frame (hereafter IERS94 and IERS95) and the radio-optical reference frame of Johnston et al. (1995) (hereafter RORF). Comparing WGRF with the latter indicates the magnitude of coordinate discrepancies to be expected between global catalogs and, to some extent, points 2 and 3 as well. Points 1 and 2 were tested by comparisons with two catalogs based on independent data and analyzed with independent software. The two catalogs are denoted "GSFC" and "JPL" and are based, respectively, on data collected at GSFC and at JPL using independent VLBI networks. The two independent data sets were analyzed respectively at GSFC using CALC/

SOLVE and at JPL using the JPL MODEST software package. Finally, point 4 was tested with three additional catalogs: WGRFna, WGRFel, and WGRFng. In the solution used to produce the WGRFna catalog, all source coordinates were treated as global parameters (i.e., no sources were arc parameters). For the WGRFel catalog, the threshold for eliminating lower elevation observations was raised from 6° to 7°. Finally, for the WGRFng catalog, no tropospheric gradient parameters were estimated in the solution. For these last three catalogs, all other parameterization of the solutions was identical to that of the WGRF solution.

Assessment of catalog comparisons relies on several measures of the overall alignment and agreement of the coordinates. Table 1 shows such results for the nine pairs of catalogs in the comparisons. The quantities A_1, A_2, and A_3 are the rotation angles about Cartesian axes to bring each pair of catalogs into best coincidence; the reduced χ^2_ν values are calculated from position differences after the rotation is applied to one catalog of the pair. Off-diagonal covariances are neglected in all comparisons. Agreements in $\alpha \cos \delta$ and δ between catalogs are indicated by rms differences about the mean; another measure is a similar quantity for arc lengths between all pairs of sources. Potentially significant internal trends in the variation of coordinate differences with α and δ are assessed by fitting linear models to all four combinations $\Delta\alpha$ versus α, δ and $\Delta\delta$ versus α, δ. The largest variations of these fits over the celestial sphere, D_{max}, as well as their significance in units of the formal uncertainty of the slope, D_{max}/σ, are reported in the last two columns of Table 1. With two exceptions, they are all in $\Delta\delta$ versus δ; the exceptions are $\Delta\alpha$ versus α for IERS95 versus IERS94 and $\Delta\delta$ versus α for WGRF versus WGRFna.

Table 1 shows that all the tested catalogs are well aligned: rotational offsets do not exceed 0.5 mas around any of the three axes. Systematic errors appear to be present, however, as indicated by the reduced χ^2_ν values of between 2 and 3 for many comparisons after the removal of the rotational offsets. Note that the rotations and the reduced χ^2_ν values are considerably smaller for the last three catalog pairs, which involve only minor modeling variations but are derived from the same data set. This result also holds true for the rms differences and trends: these remain below 0.3 and 0.2 mas per 100°, respectively. Only the inclusion of tropospheric gradients in the modeling has an appreciable impact. This is discussed in § 7.3.

The results are significantly different, however, for the first six catalog pairs. Differences are as large as 0.4 mas for coordinates and 0.6 mas for arc lengths, with trends reaching 0.7 mas per 100° with 15 σ apparent significance. The differences in coordinates are largest for the GSFC versus JPL comparison. The individual differences between these two catalogs are shown in Figure 3.

It should be noted that the significance of the systematic trends in coordinate differences is exaggerated in the results of Table 1. As noted above, these values were calculated without using off-diagonal covariances. When correlations among all source coordinates are taken into account, the significance of such trends decreases substantially. As an example, the fairly large deviations in declination visible for Southern Hemisphere sources in Figure 3 are not as significant as they appear, as these declination differences are correlated. This is an indication that the quality of the source coordinates over some limited region of the sky is considerably better than their coherence over the entire celestial sphere. The most likely source of such behavior is in the correlations among observations introduced by limitations of observing networks and schedules.

Other considerations of catalog comparisons are the level of agreement one would expect from using independent analysis software and the bias introduced by different analyst choices in editing the raw data. To address the influence of differences in software, a program of model comparison was undertaken. Three software packages (GSFC's CALC, used to generate the WGRF catalog, JPL's MODEST, and the GLORIA package of the Observatoire de Paris) were compared in detail for all observables in one 24 hr VLBI observing session. Because of software limitations, not all model components were compared, most notably the axis offsets of antennas with nonintersecting axes. Furthermore, some model components, such as different tropospheric mapping functions, were compared only within the same software package. After considerable effort to match modeling options between the different software packages, the weighted rms delay and delay rate observables output by each package were found to be in agreement to within ~ 1 ps and ~ 1 fs s^{-1}, respectively. Effects on source positions would thus be limited to errors on the order of 1 ps $\approx$ 0.3 mm, which on a 10,000 km baseline is $\sim$0.005 mas. This is approximately a factor of 60 lower than some of the systematic problems exposed in Table 1.

Having isolated modeling differences, we next built catalogs using an identical subset of the data but analyzed using different software (CALC, MODEST) and analyst choices. The rotation angles between the resulting catalogs were

TABLE 1

SUMMARY OF CATALOG DIFFERENCES

Catalog Pair	Rotation Angles (mas) A_1	A_2	A_3	χ^2_ν	RMS Residuals (mas) $\alpha \cos \delta$	δ	Arc Length	Internal Trends D_{max}*	D_{max}/σ
WGRF vs. IERS95	0.1	−0.4	0.0	2.92	0.23	0.39	0.55	0.32	14
vs. RORF	−0.2	−0.5	0.0	2.77	0.10	0.38	0.42	0.32	15
IERS95 vs. IERS94	0.0	0.0	0.0	2.85	0.30	0.31	0.52	0.29	12
WGRF vs. GSFC..........	−0.1	−0.1	−0.0	1.68	0.09	0.29	0.39	0.15	7
vs. JPL	0.1	−0.3	−0.2	2.84	0.26	0.44	0.51	0.66	15
GSFC vs. JPL	0.2	−0.3	0.2	3.42	0.30	0.36	0.58	0.38	14
WGRF vs. WGRFna......	0.2	0.0	0.0	0.18	0.05	0.06	0.12	0.07	2
vs. WGRFel	0.0	0.0	0.0	0.04	0.01	0.02	0.04	0.02	2
vs. WGRFng	0.0	−0.1	0.0	0.99	0.03	0.12	0.22	0.19	8

* In mas per 100°.

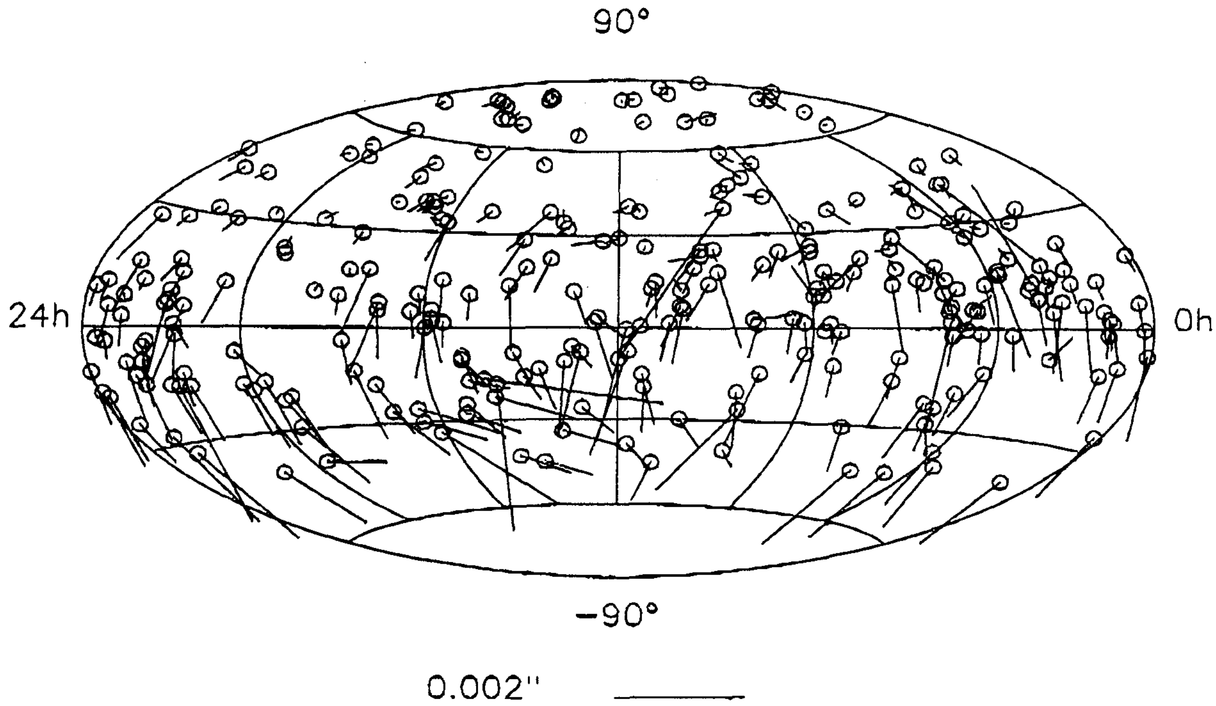

FIG. 3.—Vector differences between two catalogs based on independent data and analyzed with independent software. The two data sets were analyzed, respectively, at GSFC using their CALC/SOLVE software package and at JPL using their MODEST software package. A three-dimensional rotation between the two catalogs (listed in Table 1) has been removed. The lengths of the vectors represent the magnitude of the difference of the positions (as indicated by the key), while the orientations of the vectors represent the direction in which the positions differ on the sky. The data and the analysis used to derive the positions for these two catalogs are completely independent. The large differences in the Southern Hemisphere arise from limitations in the observing geometry of the JPL data set.

$A_1 = 0.14 \pm 0.03$ mas, $A_2 = -0.01 \pm 0.02$ mas, and $A_3 = 0.00 \pm 0.02$ mas. The bias of the coordinate means in $\alpha \cos \delta$ and δ was 0.01 and 0.02 mas, respectively. The weighted rms difference between the two catalogs was 0.15 and 0.21 mas, respectively, in $\alpha \cos \delta$ and δ.

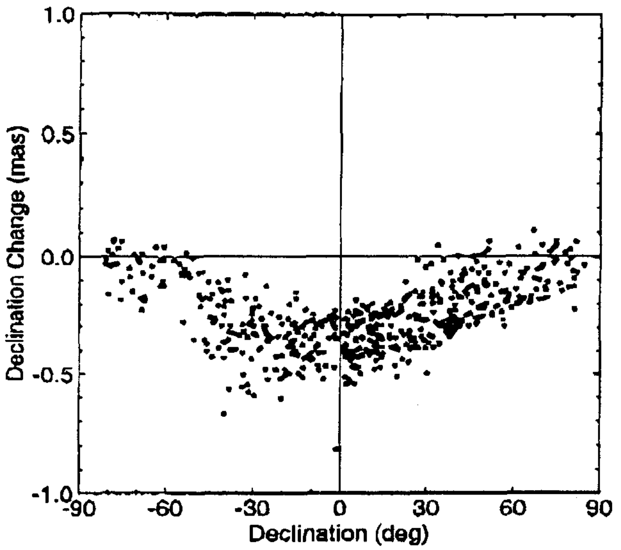

FIG. 4.—Effect of tropospheric gradients on declinations as a function of declination. The sense is declinations with gradients estimated minus declinations without gradients estimated. Points with formal errors greater than 2 σ have been omitted for clarity.

In summary, analyst choices may introduce scatter of a little less than 1 formal error (which is 0.18 and 0.29 mas in the median for $\alpha \cos \delta$ and δ, respectively) but do not significantly bias the coordinate means. The closeness of the model comparisons indicates that the discrepancies between source catalogs are determined by other factors. The model comparisons indicate that one can have very high confidence in the correctness of the model implementations.

7.3. *An Identifiable Systematic Error*

The gradients in the troposphere, estimated from the data, illustrate how a systematic effect on the source positions can arise from a discrete change in the analysis. Figure 4 shows the differences between source declinations from analyses with and without correction for estimated tropospheric gradients. The effect is much larger than the formal errors and is caused by the greater tropospheric thickness nearer the equator (MacMillan & Ma 1997). While the effect is not large in absolute terms, it is systematic and would distort the celestial reference frame if ignored. Note that the tests used for the catalog comparisons in § 7.2 also detected this nonlinear distortion.

8. ASTROPHYSICAL CAUSES FOR SOURCE POSITION VARIATIONS

Many extragalactic sources display structure on milliarcsecond scales for the strong radio emission associated with their compact cores. Temporal variations of the intrinsic structure of these objects may result in apparent motion when observations are made at several epochs. Until recent-

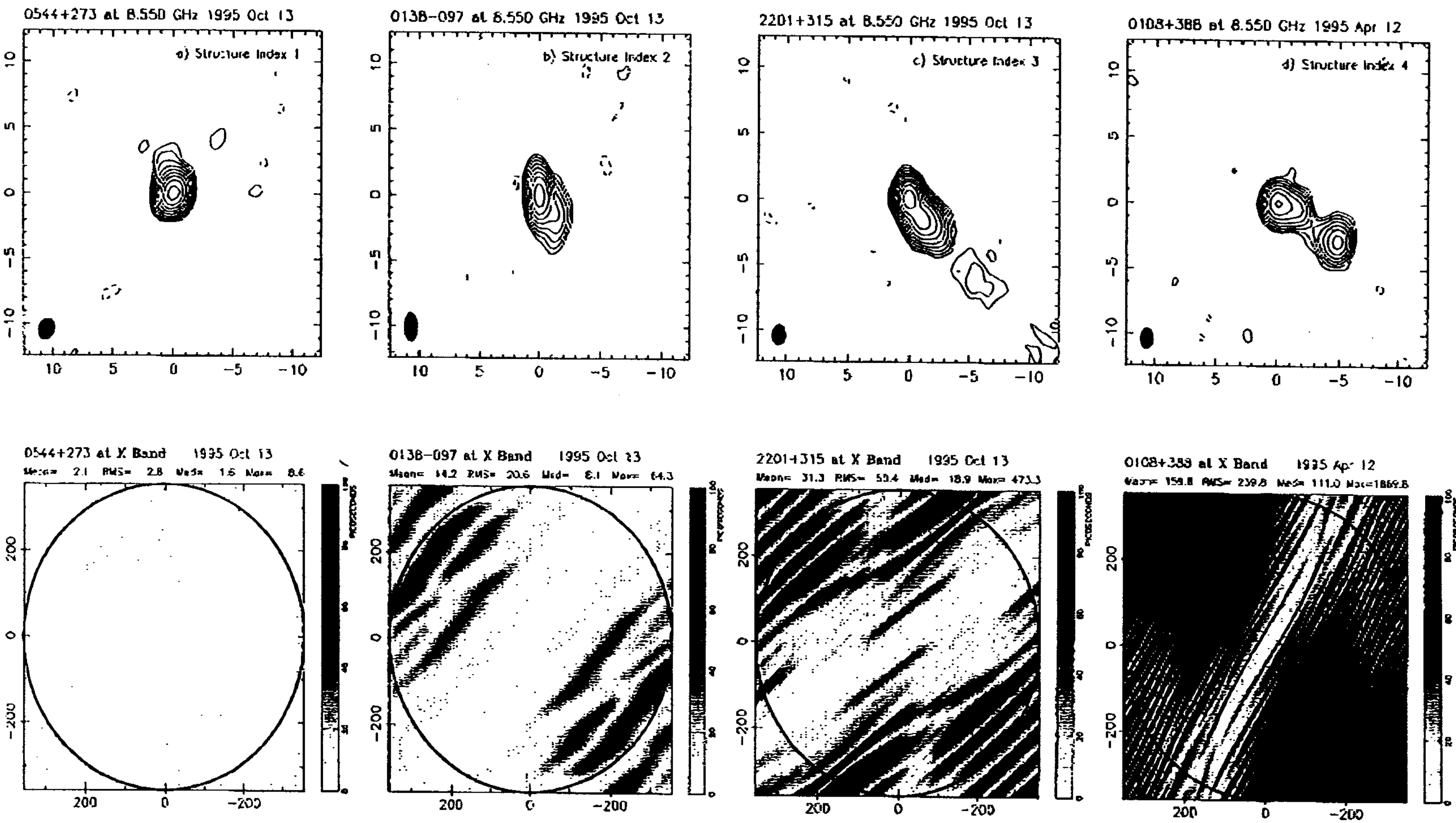

FIG. 5.—*Top*: Contour plots of the radio emission at 3.6 cm wavelength for the four sources (*a*) 0544+273, (*b*) 0138−097, (*c*) 2201+315, and (*d*) 0108+388. Tick marks are spaced 1 mas apart. Contour intervals are spaced by a factor of 2 in intensity starting at (*a*) 2.21, (*b*) 1.67, (*c*) 2.38, and (*d*) 2.41 mJy beam^{-1}. The X-band structure index is indicated in each panel. These sources are representative of each structure index class. *Bottom*: Gray-scale plots showing the magnitude of the structure correction (absolute value) induced in the bandwidth synthesis delay by the extended radio emission at the X band for the same four sources. The structure correction is plotted as a function of the length and orientation of the VLBI baseline projected onto the sky, expressed in units of millions of wavelengths (*u*-*v* plane coordinates). The gray scale is identical in each panel and ranges from 0 to 100 ps. All structure corrections greater than 100 ps are plotted as black. The circle drawn in these plots has a radius equal to one Earth diameter, corresponding to the longest baselines that can be theoretically observed with Earth-based VLBI. The mean, rms, median, and maximum values of the structure corrections for all baselines contained within this circle are indicated in each panel. The structure index classes defined by Fey & Charlot (1997) are based on the median.

ly, the intrinsic structure of the majority of the sources has been mostly unknown. The surveys of Fey, Clegg, & Fomalont (1996) and Fey & Charlot (1997) show that most sources, when examined in detail, exhibit spatial structure on milliarcsecond scales. Their results show that the variation of intrinsic structure from source to source can be quite extreme, ranging from relatively compact naked-core objects, to compact double sources, to complex core-jet objects. The situation is exacerbated by the fact that compact extragalactic radio sources are known to have variable intensity and to have frequency- and time-dependent intrinsic structure. Consequently, unknown and/or unmodeled source structure effects may be introduced into the astrometric solution.

Charlot (1990) has modeled the effects of radio source structure on measured VLBI group delays and delay rates. Results of this modeling suggest that these effects can be significant for extended sources (typically at a level of 100 ps). Fey & Charlot (1997) calculated structure corrections based on the Charlot analysis using source models derived from Very Long Baseline Array observations of 169 extragalactic sources. Results of these calculations show that intrinsic-structure contributions to the measured bandwidth synthesis delay are significant, ranging from maximum corrections of only a few picoseconds for the most compact sources to maximum corrections of several nanoseconds for the most extended sources. Fey & Charlot (1997) found a correlation between the compactness of the sources and their position formal uncertainties indicating that the more extended sources have larger position formal errors. They also define a source "structure index" based on the median of the calculated structure corrections. They suggest that this index can be used as an estimate of the astrometric quality of the sources as follows: Sources with an X-band structure index of 1 may be considered very good astrometric sources. Sources with an X-band index of 2 may be considered good sources, while sources with an X-band index of 3 should be considered marginal (and should only be used with caution). Finally, sources with an X-band index of 4 should not be used at all for astrometric work. In addition, sources should have an S-band structure index of either 1 or 2, with a preferred value of 1, regardless of the value of their X-band structure index.

Shown in Figure 5 are contour plots of the radio emission at 3.6 cm wavelength for four sources (0138−097, 0108+388, 0544+273, and 2201+315) observed by Fey & Charlot (1997). These sources are representative of each structure index class. The X-band structure index of these sources is indicated in each panel. The S-band structure index of each source is 1 with the exception of 0108+388, which has an S-band structure index of 2. Only the two sources 0544+273 (structure index 1) and 0138−097 (structure index 2) are ICRF defining sources (see § 10). Also shown in Figure 5 are the corresponding structure-effect maps. These indicate the corrections to the VLBI delay observable as a function of interferometer resolution. The mean, rms, median, and maximum values of the structure corrections calculated by Fey & Charlot (1997) for these sources are also indicated in each panel.

A caveat on the use of the structure index is worth noting at this point. The projected VLBI baselines at which structure effects will be most prominent also tend to be very near minima in the visibility function (Charlot 1990). This fact reduces the chances of a VLBI detection, and in the cases where an extended source is detected (with low amplitud and low signal-to-noise ratio), the resulting astrometri solution formal errors will be increased. The end result i that the low visibility amplitude and low signal-to-nois ratio will increase the odds that an observation of a extended source is edited out or is down-weighted in th solution. In this sense, astrometric VLBI analysis partiall compensates for structure effects. Consequently, the struc ture index should not be the sole method for classifyin sources for astrometric suitability but should be given a least equal consideration with other source selection criteri (cf. Fey & Charlot 1997).

The variations in source positions discussed in § 6.2 wer not comprehensively analyzed to determine the underlyin causes. The position variations for some sources show clea correlations with changes in intrinsic structure, and to som extent, the position changes can be derived from the struc ture, but there is no strong evidence of any regularly repeat ed behavior. There are 366 sources in the VLBI databas with sufficient observations to estimate meaningful prope motions, with 116 of these sources having proper-motior formal errors less than 50 μas yr^{-1}. Of these sources, onl 26 have proper-motion estimates statistically different from zero (at the 99.9% confidence level). Since the statisticall significant proper motions typically translate into transverse apparent velocities of 3–5 times the speed of light these motions are presumably caused by source structure changes related to the superluminal motions (i.e., motior perpendicular to the line of sight with an apparent linea velocity in excess of the speed of light) observed in components ejected from the cores of many of these same extragalactic radio sources (Vermeulen & Cohen 1994). In a fev cases (e.g., Charlot 1994; Fey et al. 1997), the observed absolute motions have been related to specific components observed in source images.

9. ESTIMATION OF REALISTIC ERRORS

From a consideration of error sources such as described in § 7, it was concluded that a realistic error estimate for the invariant source positions could be made by inflating the formal errors by a factor of 1.5 followed by a root sum square increase of 0.25 mas. For the most frequently observed sources, the 0.25 mas is the dominant error. The errors of the "arc" sources were also increased by 0.25 mas in quadrature.

The method adopted at the IERS until 1995 for the realization of the extragalactic reference frame consisted of combining individual VLBI frames by applying an algorithm based on catalog comparison. The positional uncertainties derived from the combination reflected the disagreement between individual analyses.

A similar solution was performed for this work in order to study the question of whether adopting a "unique calibration law" for all sources would eliminate or at least minimize systematic errors. Individual VLBI frames submitted by GSFC, JPL, NOAA, and USNO to the IERS in 1994 (see Charlot 1995) were included in a combination solution. The solution included parameters describing the difference between the frames (three rotation angles, drifts in right ascension and declination as functions of declination, and a bias in declination). A comparison of the "inflated" WGRF uncertainties with those obtained from the catalog combination showed that there were still a non-negligible number of sources whose inflated uncertainties were smaller than those resulting from the comparison of parallel analyses with a deformation correction model. For these sources, the uncertainty for each coordinate was set to be the *larger* of the inflated or the comparison value.

10. CATEGORIZATION OF SOURCES

Because of different observing histories and astrometric suitability, the source positions estimated from the VLBI data analysis are of varying quality. In order to define the axes of the ICRF as accurately as possible, only the highest quality positions can be used for determining or "defining" the orientation of the ICRF. The remaining, or "nondefining," sources, derived from the same solution as that of the defining sources, are included primarily to densify the frame.

To be most useful in defining the ICRF, a source should ideally show no variation of position in the data set, have sufficient data to support the absence of variation, and not have shown unexplained differences in position between realizations of equivalent validity. Several quality levels can be established for each of the 608 sources in the WGRF catalog. These levels are based on one of three sets of criteria: (1) quality of data and observation history, (2) consistency of coordinates derived from subsets of data, and (3) repercussions of source structure.

To qualify for the list of sources that could be used to orient the WGRF catalog with respect to the IERS celestial reference system, a source must meet the criteria in all three categories. An attempt to quantify the criteria follows. In category 1, a source is disqualified if it has fewer than 20 observations or if the observations span less than 2 yr. Each of the individual formal coordinate uncertainties $\sigma_{\alpha \cos \delta}$ and σ_δ from the least-squares solution (before "inflation" of the uncertainties as described in § 9) must also be smaller than 1 mas. In category 2, a source may be disqualified on the basis of the magnitude and significance of its coordinate differences in several pairwise catalog comparisons. After application of a global three-dimensional rotation to place each pair of catalogs in best coincidence, if the coordinate differences exceed 0.5 mas or 3 σ in either coordinate, the source is disqualified. In category 3, three separate tests for structure effects must be satisfied. First, the source must have shown enough positional stability so as to not qualify for "arc" position estimation. Second, the structure index at the X band, when available, must be 1 or 2 (median absolute value structure correction smaller than 10 ps). Unfortunately, at the time of the ICRF analysis, these values were only available for the 42 sources imaged by Fey et al. (1996). While the fraction of sources with available images was rather small (42 out of 608), the corresponding fraction of VLBI observations involving these sources is respectable ($\sim$55%). Finally, in subsidiary solutions that estimated time rates of change of right ascension and declination, the significance of any estimated motions must not exceed 3 σ.

The sources then fall into three categories: 212 defining sources that fail none of the above criteria, 294 candidate sources that fail some or all of the criteria, and 102 "other" sources with identified excessive position variation, either linear or random. Some candidate sources have insufficient observations or duration of observation for reliable designation as defining sources, while others with many observations may have larger than expected differences in position between catalogs. Many frequently observed sources fail to be included in the defining category. In fact, the majority of sources with more than 20,000 observatio[ns] do not pass at least one of the chosen criteria. This is mo[st] likely a reflection of the stringency of the criteria for elig[i]bility as a defining source. Candidate sources potentiall[y] could be designated defining sources in future realizatio[ns] of the ICRF as more data become available or analys[is] improves. The third category, of "other" sources, includ[es] sources that may be useful for purposes such as radi[o-] optical frame ties. While only the defining sources have [a] formal role in the ICRF, the positions of all sources ar[e] consistent with the ICRF. The VLBI database also include[s] several sources with inadequate data to estimate usef[ul] positions, as well as several radio stars. These few source[s] have been excluded from the analysis of this paper and wi[ll] not be considered further.

Well after the defining source list was finalized, addition[al] sources were imaged and their structure indexes compute[d]. Four sources (0153+744, 0518+165, 0831+557, an[d] 1532+016) with stable positions and already included i[n] the best category were found to have an X-band structur[e] index of 4. The structures of 0153+744, 0518+165, an[d] 0831+557, however, appear to be stable over time.

11. ORIENTATION OF THE ICRF

The VLBI analysis for the WGRF catalog describe[d] above provided accurate relative positions and an overal[l] orientation extremely close to that of the ICRS (Arias et al 1995). However, the solution was not designed to obtai[n] results directly on the ICRS. The final stage in the ICR[F] realization was the rigid rotation of the relative positions t[o] the ICRS maintained by the IERS. The WGRF catalog wa[s] aligned to the ICRS by rotating it onto the latest availabl[e] realization of the IERS celestial reference frame, IERS95.

Radio source coordinates in IERS95 were obtained b[y] combining individual extragalactic reference frames submitted to the IERS in 1995. The coordinates adopted for [a] set of 236 defining sources aligned the axes of IERS95 to th[e] ICRS.

Because of the model adopted in the compilation o[f] IERS95, the frame was affected by deformations comin[g] from the individual contributed catalogs. The improvements in the models and procedures applied in the WGRF solution resulted in a frame less corrupted by deformation[s] but slightly misoriented with respect to IERS95. In the procedure applied to rotate the WGRF positions to the IERS frame, care was taken not to transfer the deformations o[f] the latter to the former.

The algorithm used to put the WGRF coordinates int[o] the ICRS was based on a catalog comparison of commo[n] sources (Arias, Feissel, & Lestrade 1988). However, not all common sources contributed to the calculation of the rotation angles between the two frames. From the 212 WGRF defining sources, only 117 were defining sources in IERS95. These sources are well distributed in the Northern Hemisphere but rather sparse in the Southern Hemisphere. To obtain a better distribution of sources on the sky, an additional 16 IERS95 defining sources not in the WGRF defining list but with rather high quality were included, resulting in 133 common objects for comparison.

The ICRF extragalactic frame was obtained by putting the radio source coordinates from the WGRF solution on the ICRS via comparison with IERS95. Relative orientation and deformation parameters to transform IERS95 to WGRF are listed in Table 2. The parameters A_1, A_2, and

TABLE 2

ALIGNMENT OF THE ICRF AXES WITH THE ICRS

Parameter	Value
A_1 (mas)	-0.006 ± 0.018
A_2 (mas)	0.007 ± 0.018
A_3 (mas)	0.005 ± 0.021
D_α (mas per 100°)............	0.0
D_δ (mas per 100°)............	0.2
B_δ (mas)	-0.28 ± 0.02
$\mathrm{wrms}_{\alpha\cos\delta}$ (mas)	0.14
wrms_δ (mas)	0.20

A_3 are the rotation angles between axes of the frames; D_α and D_δ are the linear trends in right ascension and declination, respectively, as a function of declination; and B_δ is a declination bias parameter (Feissel & Essaifi 1994, p. II-25). All of these parameters have been adjusted on the basis of the 133 common defining sources. The quantities $\mathrm{wrms}_{\alpha\cos\delta}$ and wrms_δ are the weighted rms residuals in $\alpha \cos \delta$ and δ, respectively.

Table 2 shows that the axes of both frames are aligned to better than 0.02 mas. The deformation of IERS95 relative to WGRF is represented mainly by a bias of the principal plane. To test the stability of the axes of the system, we estimated the relative orientation between WGRF and IERS95 on the basis of different subsets of sources. The scatter of the rotation parameters obtained in the different comparisons indicates that the axes are stable to within 0.02 mas.

12. THE ICRF CATALOG

The positions, errors, $C_{\alpha\text{-}\delta}$ (the correlations between right ascension and declination), and observation and session statistics of the ICRF defining sources are given in Table Similar information for the candidate and "other" sourc given in Tables 4 and 5, respectively. The X-band an S-band structure indexes are given where available, an *Hipparcos* link sources (see Kovalevsky et al. 1997) are als identified. Ancillary information, such as source typ source redshift, and VLBI images, can be found in Ma & Feissel (1997).[3]

Figures 6, 7, 8, and 9 show the distribution of "inflated position errors for the sources by category. Figures 10, 1 12, and 13 show the distributions of the objects on the sk for the same four categories. From these figures it can b seen that there is a moderately even distribution of a sources over the sky but that the Southern Hemisphere i deficient in defining sources. This is caused by the sma number of VLBI stations in the Southern Hemisphere an by limited observing programs. While all sources are give ICRF designations, it should be emphasized that th quality and intended use of the three categories are quit different. The best astrometric quality resides in the definin sources and those candidate sources with the smalles errors. The positions of the "other" sources should be use carefully and only where less accuracy can be tolerated.

13. ADOPTION OF THE ICRF BY THE INTERNATIONAL ASTRONOMICAL UNION

According to resolution JD7 N.1, adopted by the 23 General Assembly of the IAU on 1997 August 20 in Kyoto

[3] Position tables and ancillary information can also be obtained from the IERS at http://hpiers.obspm.fr or from the National Earth Orientation Service at http://maia.usno.navy.mil.

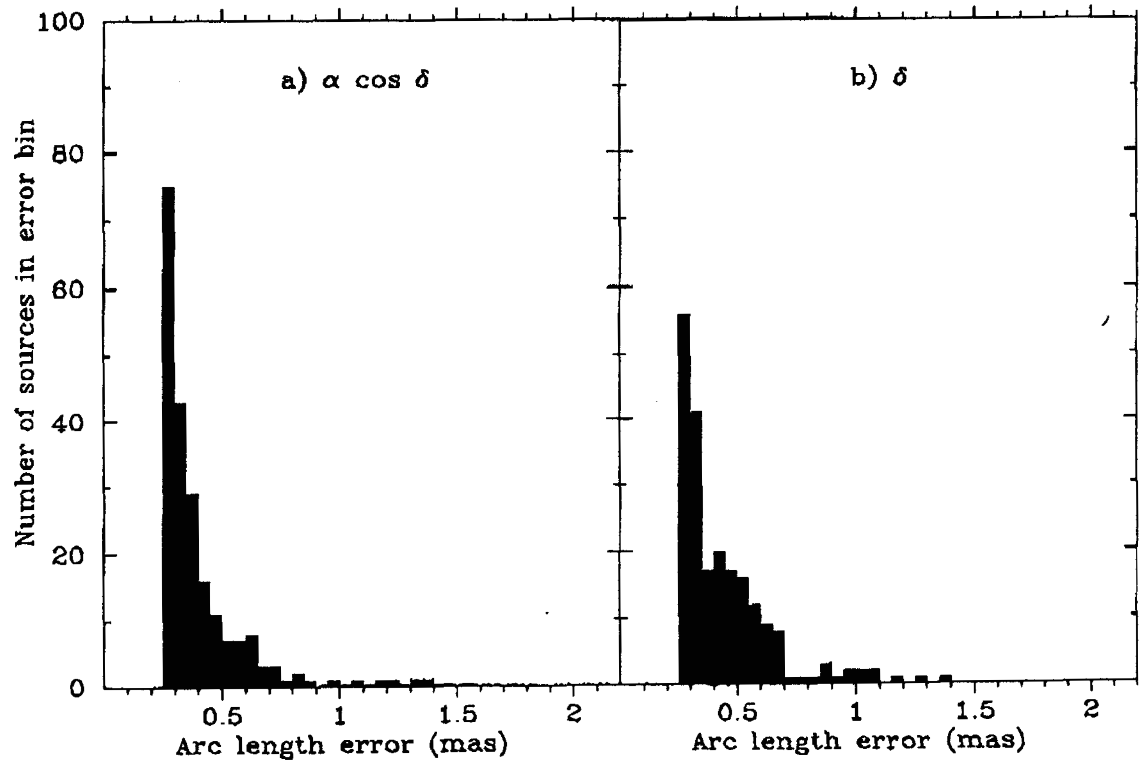

FIG. 6.—Histograms of source position errors for defining sources in (*a*) $\alpha \cos \delta$ and (*b*) δ

TABLE 3

COORDINATES OF THE 212 DEFINING SOURCES IN THE ICRF

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	Epoch of Observation[d] First	Epoch of Observation[d] Last	N_{exp}[e]	N_{obs}[f]
ICRF J000557.1+382015......	0003+380	...	...		00 05 57.175409	38 20 15.14857	0.000041	0.00051	−0.041	49,087.0	48,720.9	49,554.8	2	41
ICRF J001031.0+105829......	0007+106	...	...		00 10 31.005888	10 58 29.50412	0.000032	0.00068	0.540	47,938.9	47,288.7	49,690.0	10	74
ICRF J001033.9+172418......	0007+171	...	...		00 10 33.990619	17 24 18.76135	0.000021	0.00035	−0.402	48,730.8	47,931.6	49,662.8	19	57
ICRF J001331.1+405137......	0010+405	2	1		00 13 31.130213	40 51 37.14407	0.000026	0.00034	−0.038	49,549.6	48,434.7	49,820.5	7	219
ICRF J001708.4+813508......	0014+813	...	...		00 17 08.474953	81 35 08.13633	0.000121	0.00026	0.012	49,505.2	47,023.7	49,924.8	78	1453
ICRF J004204.5+232001......	0039+230	...	...		00 42 04.545183	23 20 01.06129	0.000036	0.00060	0.090	48,898.1	48,328.5	49,533.8	3	44
ICRF J004959.4−573827......	0047−579	...	...		00 49 59.473091	−57 38 27.33992	0.000047	0.00053	0.298	48,697.0	47,626.5	49,407.6	13	46
ICRF J011205.8+224438......	0109+224	...	...	Y	01 12 05.824718	22 44 38.78619	0.000027	0.00049	0.082	48,733.1	48,434.7	49,736.9	7	97
ICRF J012642.7+255901......	0123+257	...	...		01 26 42.792631	25 59 01.30079	0.000030	0.00054	0.167	48,856.4	48,328.5	49,659.8	4	71
ICRF J013305.7−520003......	0131−522	...	...		01 33 05.762585	−52 00 03.94693	0.000049	0.00081	0.399	49,039.1	48,162.4	49,895.6	6	30
ICRF J013658.5+475129......	0133+476	2	2		01 36 58.594810	47 51 29.10006	0.000026	0.00027	0.021	48,629.0	45,138.8	49,750.8	190	2196
ICRF J013738.3−243053......	0135−247	...	...		01 37 38.346378	−24 30 53.88526	0.000055	0.00042	−0.188	48,321.8	47,640.2	49,790.7	3	29
ICRF J014125.8−092843......	0138−097	2	1		01 41 25.832025	−09 28 43.67381	0.000081	0.00088	0.063	47,138.1	46,875.8	49,498.8	2	20
ICRF J015127.1+274441......	0148+274	...	...		01 51 27.146149	27 44 41.79365	0.000031	0.00043	−0.064	48,963.9	48,328.5	49,659.8	5	112
ICRF J015218.0+220707......	0149+218	...	...		01 52 18.059047	22 07 07.70004	0.000020	0.00029	−0.437	48,294.0	46,977.9	49,848.8	50	243
ICRF J015734.9+744243......	0153+744	4	3	Y	01 57 34.964908	74 42 43.22998	0.000091	0.00031	0.059	49,495.7	47,019.9	49,820.5	11	400
ICRF J020333.3+723253......	0159+723	...	...		02 03 33.385004	72 32 53.66741	0.000072	0.00031	0.033	48,800.7	47,011.4	49,667.9	17	108
ICRF J020504.9+321230......	0202+319	...	...		02 05 04.925371	32 12 30.09560	0.000022	0.00030	−0.441	48,017.7	45,466.3	49,736.9	35	214
ICRF J021748.9+014449......	0215+015	1	1		02 17 48.954740	01 44 49.69909	0.000022	0.00039	−0.215	49,302.1	48,328.5	49,547.8	5	133
ICRF J022239.6+430207......	0219+428	...	...		02 22 39.611500	43 02 07.79884	0.000034	0.00043	−0.098	49,103.6	48,650.8	49,554.8	7	64
ICRF J022256.4−344128......	0220−349	...	...		02 22 56.401625	−34 41 28.73011	0.000050	0.00044	−0.209	48,679.5	47,640.2	49,790.7	4	35
ICRF J022850.0+672103......	0224+671	...	...		02 28 50.051459	67 21 03.02926	0.000052	0.00031	−0.080	45,097.6	44,090.5	49,600.3	42	801
ICRF J022934.9−784745......	0230−790	...	...		02 29 34.946647	−78 47 45.60129	0.000149	0.00049	0.028	48,828.1	47,626.5	49,895.6	11	52
ICRF J023838.9+163659......	0235+164	1	1		02 38 38.930108	16 36 59.27471	0.000018	0.00027	0.090	47,475.7	44,447.0	49,909.6	194	2595
ICRF J024229.1+110100......	0239+108	2	2		02 42 29.170847	11 01 00.72823	0.000018	0.00030	−0.483	48,582.3	47,511.1	49,662.8	43	153
ICRF J025134.5+431515......	0248+430	...	...		02 51 34.536779	43 15 15.82858	0.000027	0.00033	−0.074	49,109.4	47,931.6	49,690.0	10	169
ICRF J025927.0+074739......	0256+075	...	...		02 59 27.076633	07 47 39.64323	0.000021	0.00035	−0.607	48,247.0	47,011.4	49,445.6	44	190
ICRF J030350.6−621125......	0302−623	...	...		03 03 50.631333	−62 11 25.54983	0.000047	0.00033	0.129	49,059.2	48,162.4	49,650.8	15	97
ICRF J030903.6+102916......	0306+102	...	...		03 09 03.623523	10 29 16.34082	0.000023	0.00042	−0.804	48,974.1	47,394.1	49,667.9	18	76
ICRF J030956.0−605839......	0308−611	...	...		03 09 56.099167	−60 58 39.05628	0.000038	0.00029	0.037	49,029.5	47,626.5	49,895.6	79	738
ICRF J031301.9+412001......	0309+411	...	...	Y	03 13 01.962129	41 20 01.18353	0.000026	0.00031	−0.321	48,371.0	47,165.8	49,848.8	29	127
ICRF J034506.4+145349......	0342+147	...	...		03 45 06.416546	14 53 49.55818	0.000021	0.00032	−0.622	48,809.6	47,394.1	49,445.6	23	177
ICRF J040305.5+260001......	0400+258	3	2	Y	04 03 05.586048	26 00 01.50274	0.000020	0.00030	−0.127	48,990.5	47,005.8	49,820.5	37	397
ICRF J040922.0+121739......	0406+121	2	1		04 09 22.008740	12 17 39.84750	0.000021	0.00033	−0.704	48,399.2	46,977.9	49,565.9	28	149
ICRF J041636.5−185108......	0414−189	...	...		04 16 36.544466	−18 51 08.34012	0.000051	0.00048	−0.078	47,814.6	46,840.8	49,790.7	3	31
ICRF J042442.2−375620......	0422−380	...	...		04 24 42.243727	−37 56 20.78423	0.000033	0.00119	0.251	49,081.7	48,162.4	49,750.8	11	60
ICRF J042446.8+003606......	0422+004	2	1		04 24 46.842052	00 36 06.32983	0.000020	0.00063	0.038	48,938.2	45,997.8	49,820.5	11	245
ICRF J042636.6+051819......	0423+051	...	...		04 26 36.604102	05 18 19.87204	0.000031	0.00087	0.101	48,977.3	48,194.7	49,667.9	9	64
ICRF J042840.4−375619......	0426−380	...	...		04 28 40.424306	−37 56 19.58031	0.000036	0.00047	0.011	48,125.7	47,640.2	49,692.6	5	39
ICRF J043900.8−452222......	0437−454	...	...		04 39 00.854714	−45 22 22.56260	0.000057	0.00078	−0.123	49,443.5	48,766.9	49,895.6	7	32
ICRF J044238.6−001743......	0440−003	1	1		04 42 38.660762	−00 17 43.41910	0.000025	0.00064	0.262	47,735.2	47,011.4	49,576.9	15	111
ICRF J044907.6+112128......	0446+112	...	...		04 49 07.671119	11 21 28.59662	0.000024	0.00051	−0.143	49,312.0	47,394.1	49,854.8	5	32
ICRF J045005.4−810102......	0454−810	...	...		04 50 05.440195	−81 01 02.23146	0.000137	0.00032	−0.005	48,784.2	47,626.5	49,895.6	18	148
ICRF J045952.0+022931......	0457+024	...	...		04 59 52.050664	02 29 31.17631	0.000019	0.00032	0.062	48,993.4	47,005.8	49,750.8	36	394
ICRF J050145.2+135607......	0458+138	2	2		05 01 45.270840	13 56 07.22063	0.000037	0.00064	−0.770	48,830.7	47,394.1	49,848.8	13	20
ICRF J050523.1+045942......	0502+049	...	...		05 05 23.184723	04 59 42.72448	0.000037	0.00060	−0.584	48,897.7	47,394.1	49,667.9	6	28
ICRF J050643.9−610940......	0506−612	...	...		05 06 43.988739	−61 09 40.99328	0.000047	0.00035	0.145	48,760.5	48,110.9	49,594.7	16	69
ICRF J050842.3+843204......	0454+844	...	...		05 08 42.363503	84 32 04.54402	0.000194	0.00028	−0.046	48,674.7	46,977.9	49,611.9	42	250
ICRF J051002.3+180041......	0507+179	2	2		05 10 02.369122	18 00 41.58171	0.000020	0.00030	−0.396	49,401.9	47,605.1	49,820.5	24	339
ICRF J051644.9−620705......	0516−621	...	...		05 16 44.926178	−62 07 05.38930	0.000048	0.00042	0.202	49,455.4	48,749.6	49,895.6	9	56

TABLE 3—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	First	Last	N_{exp}[e]	N_{obs}[f]
ICRF J052109.8+163822......	0518+165	4	4		05 21 09.886021	16 38 22.05122	0.000048	0.00101	0.569	48,535.4	47,931.6	49,659.8	9	77
ICRF J052257.9−362730......	0521−365	...	...	Y	05 22 57.984651	−36 27 30.85092	0.000036	0.00106	0.404	49,078.4	48,110.9	49,895.6	6	25
ICRF J052930.0−724528......	0530−727	...	...		05 29 30.042235	−72 45 28.50731	0.000073	0.00035	−0.149	48,819.8	47,626.5	49,911.8	50	200
ICRF J053954.2−283955......	0537−286	...	...		05 39 54.281429	−28 39 55.94745	0.000036	0.00046	0.282	48,980.5	48,573.8	49,629.6	18	58
ICRF J054138.0−054149......	0539−057	2	1		05 41 38.083384	−05 41 49.42839	0.000019	0.00046	−0.188	49,489.2	47,176.5	49,820.5	6	173
ICRF J054236.1+495107......	0538+498	...	...		05 42 36.137916	49 51 07.23356	0.000053	0.00054	0.185	49,065.1	48,538.8	49,533.8	4	45
ICRF J054734.1+272156......	0544+273	1	1		05 47 34.148941	27 21 56.84240	0.000032	0.00043	−0.730	49,054.4	47,394.1	49,659.8	14	34
ICRF J055932.0+235353......	0556+238	...	...		05 59 32.033133	23 53 53.92690	0.000022	0.00032	−0.591	48,492.7	47,394.1	49,848.8	28	57
ICRF J061423.8+604621......	0609+607	3	2		06 14 23.866195	60 46 21.75538	0.000044	0.00034	0.058	48,014.6	45,466.3	49,498.8	16	217
ICRF J062603.0+820225......	0615+820	...	...		06 26 03.006188	82 02 25.56764	0.000142	0.00030	0.009	48,606.5	47,019.9	49,600.3	30	230
ICRF J063111.9−415426......	0629−418	...	...		06 31 11.998059	−41 54 26.94611	0.000086	0.00095	−0.001	48,257.9	47,626.5	49,790.7	6	24
ICRF J063546.5−751616......	0637−752	...	...	Y	06 35 46.507934	−75 16 16.81533	0.000071	0.00027	0.005	49,058.3	47,626.5	49,911.8	156	2417
ICRF J064204.2+675835......	0636+680	1	1		06 42 04.257418	67 58 35.62085	0.000053	0.00030	−0.086	49,495.2	48,357.8	49,820.5	29	550
ICRF J064632.0+445116......	0642+449	1	1		06 46 32.025985	44 51 16.59013	0.000024	0.00027	0.070	49,389.0	45,466.3	49,924.8	86	1250
ICRF J065024.5−163739......	0648−165	...	...		06 50 24.581852	−16 37 39.72500	0.000042	0.00070	−0.059	47,534.9	46,875.8	49,594.7	2	33
ICRF J071046.1+473211......	0707+476	2	1		07 10 46.104900	47 32 11.14267	0.000028	0.00029	0.003	49,334.4	46,977.9	49,820.5	9	326
ICRF J072153.4+712036......	0716+714	...	...	Y	07 21 53.448459	71 20 36.36339	0.000058	0.00028	0.092	48,388.0	47,165.8	49,750.8	115	688
ICRF J072516.8+142513......	0722+145	...	...		07 25 16.807752	14 25 13.74684	0.000023	0.00046	0.001	48,703.8	47,394.1	49,694.8	10	62
ICRF J072550.6−005456......	0723−008	3	2		07 25 50.639953	−00 54 56.54438	0.000019	0.00034	−0.190	48,083.7	44,773.8	49,820.5	19	334
ICRF J072611.7+791131......	0718+792	2	1		07 26 11.735177	79 11 31.01624	0.000097	0.00027	0.060	49,787.0	48,223.7	49,924.8	38	1457
ICRF J073545.8−173548......	0733−174	...	...		07 35 45.812508	−17 35 48.50131	0.000061	0.00138	−0.342	48,915.0	45,900.1	49,272.7	7	48
ICRF J073856.4−673550......	0738−674	...	...		07 38 56.496292	−67 35 50.82583	0.000090	0.00052	0.054	49,189.4	47,626.5	49,895.6	7	33
ICRF J074110.7+311200......	0738+313	...	...		07 41 10.703308	31 12 00.22862	0.000022	0.00029	0.031	48,627.1	45,466.3	49,848.8	22	512
ICRF J074625.8+254902......	0743+259	...	...		07 46 25.874166	25 49 02.13488	0.000033	0.00066	−0.372	48,511.9	47,407.6	49,498.8	6	21
ICRF J074836.1+240024......	0745+241	...	...		07 48 36.109278	24 00 24.11018	0.000019	0.00028	−0.022	48,240.5	47,517.4	49,600.3	114	617
ICRF J075301.3+535259......	0749+540	1	1		07 53 01.384573	53 52 59.63716	0.000030	0.00027	0.060	49,755.0	45,775.8	49,897.8	37	2087
ICRF J075706.6+095634......	0754+100	...	...		07 57 06.642936	09 56 34.85210	0.000021	0.00034	−0.086	47,266.2	45,997.8	49,848.8	15	215
ICRF J080839.6+495036......	0804+499	1	1		08 08 39.666274	49 50 36.53046	0.000027	0.00026	0.081	49,582.5	47,165.8	49,924.8	155	9947
ICRF J080856.6+405244......	0805+410	2	1		08 08 56.652038	40 52 44.88889	0.000023	0.00027	0.050	49,673.4	48,720.9	49,897.8	36	1519
ICRF J081525.9+363515......	0812+367	...	...		08 15 25.944824	36 35 15.14830	0.000031	0.00046	0.189	47,764.8	45,775.8	49,554.8	6	75
ICRF J082057.4−125859......	0818−128	...	...	Y	08 20 57.447616	−12 58 59.16949	0.000029	0.00046	−0.480	48,831.3	47,512.0	49,896.8	8	37
ICRF J082447.2+555242......	0820+560	2	1		08 24 47.236351	55 52 42.66938	0.000031	0.00026	0.054	49,263.8	46,977.9	49,848.8	48	2072
ICRF J082455.4+391641......	0821+394	...	...		08 24 55.483865	39 16 41.90430	0.000029	0.00037	0.164	48,624.1	48,194.7	49,576.9	9	102
ICRF J082804.7−373106......	0826−373	...	...	Y	08 28 04.780268	−37 31 06.28064	0.000051	0.00050	−0.053	48,454.6	47,511.1	49,629.6	9	48
ICRF J083148.8+042939......	0829+046	...	...		08 31 48.876955	04 29 39.08534	0.000026	0.00053	−0.018	49,137.6	48,649.8	49,533.8	4	59
ICRF J083223.2+491321......	0828+493	...	...		08 32 23.216688	49 13 21.03823	0.000031	0.00037	0.078	48,526.3	47,023.7	49,498.8	18	133
ICRF J083454.9+553421......	0831+557	4	3		08 34 54.903997	55 34 21.07080	0.000097	0.00068	0.096	48,902.3	47,931.6	49,456.8	8	70
ICRF J083639.2−201659......	0834−201	...	...		08 36 39.215215	−20 16 59.50350	0.000035	0.00071	−0.113	47,992.1	46,840.8	49,650.8	5	33
ICRF J083722.4+582501......	0833+585	3	1		08 37 22.409733	58 25 01.84521	0.000043	0.00031	0.060	49,393.6	46,977.9	49,820.5	19	334
ICRF J084205.0+183540......	0839+187	...	...		08 42 05.094180	18 35 40.99061	0.000026	0.00048	0.243	48,609.7	47,875.8	49,659.8	8	118
ICRF J085441.9+575729......	0850+581	...	...		08 54 41.996385	57 57 29.93928	0.000055	0.00044	−0.252	49,254.7	48,720.9	49,533.8	3	56
ICRF J090303.9+465104......	0859+470	3	2		09 03 03.990103	46 51 04.13753	0.000026	0.00028	0.029	48,772.2	47,005.8	49,820.5	107	653
ICRF J091552.4+293324......	0912+297	1	1	Y	09 15 52.401620	29 33 24.04274	0.000032	0.00057	0.223	49,057.0	48,194.7	49,659.8	7	100
ICRF J092058.4+444153......	0917+449	...	...		09 20 58.458480	44 41 53.98502	0.000026	0.00030	−0.124	48,755.5	46,977.9	49,600.3	28	141
ICRF J092136.2+621552......	0917+624	2	1		09 21 36.231054	62 15 52.18035	0.000039	0.00027	0.030	49,215.0	45,775.8	49,820.5	11	477
ICRF J094855.3+403944......	0945+408	2	2		09 48 55.338145	40 39 44.58719	0.000027	0.00033	0.094	48,666.4	47,931.6	49,659.8	9	123
ICRF J095456.8+174331......	0952+179	...	...		09 54 56.823626	17 43 31.22242	0.000024	0.00053	−0.040	48,755.5	48,158.8	49,565.9	15	91
ICRF J095819.6+472507......	0955+476	1	1		09 58 19.671648	47 25 07.84250	0.000026	0.00026	0.039	49,398.1	48,720.9	49,924.8	335	11583
ICRF J095820.9+322402......	0955+326	...	...	Y	09 58 20.949621	32 24 02.20929	0.000031	0.00047	0.081	48,569.4	47,761.7	49,554.8	6	101
ICRF J095847.2+653354......	0954+658	...	...		09 58 47.245101	65 33 54.81806	0.000042	0.00026	0.017	48,614.9	46,976.8	49,883.8	236	7668
ICRF J101447.0+230116......	1012+232	...	...		10 14 47.065445	23 01 16.57091	0.000024	0.00039	−0.344	48,580.3	47,407.6	49,576.9	11	83

TABLE 3—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	First	Last	N_{exp}[e]	N_{obs}[f]
ICRF J102311.5+394815......	1020+400	3	1		10 23 11.565623	39 48 15.38539	0.000029	0.00036	0.017	48,469.6	46,977.9	49,694.8	9	116
ICRF J103303.7+411606......	1030+415	...	...		10 33 03.707841	41 16 06.23297	0.000042	0.00044	0.195	47,892.4	47,019.9	49,498.8	12	82
ICRF J103502.1−201134......	1032−199	...	...		10 35 02.155274	−20 11 34.35975	0.000050	0.00048	0.050	48,645.5	47,176.5	49,790.7	4	33
ICRF J104117.1+061016......	1038+064	3	1		10 41 17.162504	06 10 16.92378	0.000020	0.00035	−0.423	48,204.3	47,568.6	49,736.9	16	114
ICRF J104146.7+523328......	1038+528	...	...		10 41 46.781639	52 33 28.23127	0.000029	0.00028	0.061	49,331.0	48,524.8	49,883.8	43	525
ICRF J104148.8+523355......	1038+529	...	...		10 41 48.897638	52 33 55.60790	0.000073	0.00056	−0.323	49,506.7	48,650.8	49,883.8	12	67
ICRF J104244.6+120331......	1040+123	...	...		10 42 44.605212	12 03 31.26407	0.000024	0.00040	−0.077	48,805.3	47,659.7	49,790.7	9	89
ICRF J104423.0+805439......	1039+811	...	...		10 44 23.062554	80 54 39.44303	0.000117	0.00027	0.009	48,930.0	47,288.7	49,694.8	34	266
ICRF J105148.7+211952......	1049+215	2	1		10 51 48.789073	21 19 52.31411	0.000020	0.00030	0.018	49,497.7	47,931.6	49,820.5	6	218
ICRF J105811.5+811432......	1053+815	1	1		10 58 11.535365	81 14 32.67521	0.000118	0.00027	0.095	49,403.8	47,453.0	49,909.6	92	1916
ICRF J105843.3−800354......	1057−797	...	...		10 58 43.309786	−80 03 54.15949	0.000106	0.00027	0.004	49,023.8	47,626.5	49,911.8	148	2004
ICRF J111358.6+144226......	1111+149	...	...		11 13 58.695097	14 42 26.95262	0.000023	0.00042	−0.107	48,224.7	47,005.8	49,456.8	16	149
ICRF J111857.3+123441......	1116+128	3	2		11 18 57.301443	12 34 41.71806	0.000018	0.00031	−0.156	49,282.2	47,274.8	49,820.5	23	243
ICRF J113053.2+381518......	1128+385	1	1		11 30 53.282612	38 15 18.54707	0.000022	0.00026	−0.042	49,534.8	45,775.8	49,924.8	175	7357
ICRF J113320.0+004052......	1130+009	2	1		11 33 20.055797	00 40 52.83720	0.000022	0.00051	−0.515	49,111.9	47,019.9	49,820.5	23	211
ICRF J114608.1−244732......	1143−245	...	...		11 46 08.103374	−24 47 32.89681	0.000080	0.00068	−0.205	48,071.1	47,640.2	49,895.6	3	33
ICRF J115019.2+241753......	1147+245	...	...		11 50 19.212173	24 17 53.83503	0.000045	0.00063	−0.108	49,039.0	48,720.9	49,533.8	2	23
ICRF J115113.4−672811......	1148−671	...	...		11 51 13.426591	−67 28 11.09423	0.000088	0.00059	0.431	48,705.2	48,043.8	49,407.6	5	33
ICRF J115312.4+805829......	1150+812	2	2		11 53 12.499130	80 58 29.15451	0.000114	0.00027	0.009	49,157.4	46,976.8	49,820.5	41	1058
ICRF J115324.4+493108......	1150+497	...	...	Y	11 53 24.466626	49 31 08.83014	0.000036	0.00037	0.296	48,715.7	47,931.6	49,694.8	6	80
ICRF J115825.7+245017......	1155+251	...	...		11 58 25.787505	24 50 17.96369	0.000037	0.00060	0.266	48,860.8	48,179.7	49,659.8	7	78
ICRF J121555.6+344815......	1213+350	3	1		12 15 55.601049	34 48 15.22053	0.000027	0.00035	0.014	49,425.3	48,194.7	49,820.5	11	298
ICRF J121752.0+300700......	1215+303	...	...		12 17 52.081987	30 07 00.63625	0.000030	0.00054	0.198	48,795.4	48,434.7	49,667.9	5	77
ICRF J121906.4+482956......	1216+487	...	...		12 19 06.414733	48 29 56.16497	0.000032	0.00032	0.081	48,755.8	46,977.9	49,736.9	12	204
ICRF J122222.5+041315......	1219+044	2	1		12 22 22.549618	04 13 15.77630	0.000017	0.00026	−0.238	49,589.0	48,378.8	49,924.8	237	7633
ICRF J122340.4+804004......	1221+809	2	1		12 23 40.493698	80 40 04.34031	0.000123	0.00030	−0.088	49,531.2	48,022.7	49,820.5	9	515
ICRF J122847.4+370612......	1226+373	1	1		12 28 47.423662	37 06 12.09578	0.000027	0.00032	−0.073	49,313.1	48,378.8	49,750.8	6	167
ICRF J123924.5+073017......	1236+077	2	1		12 39 24.588312	07 30 17.18909	0.000021	0.00042	−0.068	49,639.0	48,378.8	49,820.5	4	163
ICRF J123946.6−684530......	1236−684	...	...		12 39 46.651396	−68 45 30.89260	0.000155	0.00100	−0.358	49,261.0	48,043.8	49,895.6	3	24
ICRF J125438.2+114105......	1252+119	...	...		12 54 38.255601	11 41 05.89507	0.000019	0.00032	−0.035	48,651.0	46,977.9	49,848.8	36	241
ICRF J125459.9−713818......	1251−713	...	...		12 54 59.921421	−71 38 18.43664	0.000066	0.00032	0.067	48,770.8	47,626.5	49,692.6	19	144
ICRF J130020.9+141718......	1257+145	...	...		13 00 20.918799	14 17 18.53107	0.000038	0.00063	0.297	49,383.4	48,804.9	49,690.0	10	59
ICRF J131028.6+322043......	1308+326	1	1		13 10 28.663845	32 20 43.78295	0.000020	0.00026	−0.152	49,096.1	44,773.8	49,924.8	869	40832
ICRF J132700.8+221050......	1324+224	...	...	Y	13 27 00.861311	22 10 50.16306	0.000020	0.00031	−0.534	48,961.9	48,429.0	49,736.9	37	116
ICRF J134345.9+660225......	1342+662	2	1		13 43 45.959534	66 02 25.74503	0.000059	0.00035	−0.014	49,242.0	47,783.2	49,611.9	6	116
ICRF J134408.6+660611......	1342+663	...	...		13 44 08.679674	66 06 11.64381	0.000047	0.00029	0.144	48,481.3	47,453.0	49,848.8	36	226
ICRF J134934.6+534117......	1347+539	3	2		13 49 34.656623	53 41 17.04028	0.000034	0.00032	−0.001	49,519.9	47,931.6	49,820.5	10	358
ICRF J141908.1+062834......	1416+067	2	1		14 19 08.180173	06 28 34.80349	0.000083	0.00129	0.186	49,420.1	48,194.7	49,820.5	8	118
ICRF J141946.5+542314......	1418+546	...	...	Y	14 19 46.597401	54 23 14.78721	0.000031	0.00027	−0.048	47,698.1	45,138.8	49,848.8	130	2179
ICRF J143645.8+633637......	1435+638	...	...	Y	14 36 45.802138	63 36 37.86658	0.000048	0.00033	0.141	48,265.6	47,023.7	49,611.9	12	192
ICRF J144516.4+095836......	1442+101	...	...		14 45 16.465213	09 58 36.07244	0.000027	0.00040	0.430	48,733.3	47,011.4	49,883.8	33	200
ICRF J144815.0−162024......	1445−161	...	...		14 48 15.054162	−16 20 24.54888	0.000030	0.00043	−0.865	48,520.9	47,605.1	49,565.9	18	39
ICRF J144828.7+760111......	1448+762	...	...		14 48 28.778877	76 01 11.59717	0.000176	0.00045	0.285	48,457.2	47,019.9	49,554.8	8	67
ICRF J150048.6+475115......	1459+480	2	1		15 00 48.654199	47 51 15.53826	0.000034	0.00038	0.118	48,587.3	47,459.8	49,554.8	9	98
ICRF J150609.5+373051......	1504+377	...	...		15 06 09.529958	37 30 51.13241	0.000024	0.00029	−0.091	49,017.6	46,977.9	49,611.9	18	198
ICRF J151656.7+193212......	1514+197	...	...		15 16 56.796194	19 32 12.99187	0.000026	0.00049	−0.040	48,620.5	48,434.7	49,533.8	5	91
ICRF J153452.4+013104......	1532+016	4	2		15 34 52.453675	01 31 04.20657	0.000020	0.00049	−0.539	48,646.8	47,407.6	49,576.9	23	110
ICRF J154049.4+144745......	1538+149	...	...		15 40 49.491511	14 47 45.88485	0.000019	0.00030	−0.536	48,426.7	45,138.8	49,790.7	39	201
ICRF J154917.4+503805......	1547+507	...	...		15 49 17.468534	50 38 05.78820	0.000035	0.00036	0.345	48,164.7	47,005.8	49,498.8	11	106
ICRF J155658.8−791404......	1549−790	...	...		15 56 58.869899	−79 14 04.28134	0.000111	0.00032	0.105	48,792.8	47,626.5	49,895.6	15	156
ICRF J160207.2+332653......	1600+335	3	1		16 02 07.263468	33 26 53.07267	0.000027	0.00053	−0.159	49,180.9	48,103.5	49,694.8	9	43

TABLE 3—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	First	Last	N_{exp}[e]	N_{obs}[f]
ICRF J160734.7−333108......	1604−333	...	...		16 07 34.762344	−33 31 08.91313	0.000047	0.00048	−0.881	49,164.5	48,393.7	49,790.7	15	39
ICRF J160846.2+102907......	1606+106	2	1		16 08 46.203179	10 29 07.77585	0.000017	0.00026	−0.426	49,344.4	45,138.8	49,924.8	533	18985
ICRF J161903.6+061302......	1616+063	...	...		16 19 03.687684	06 13 02.24357	0.000028	0.00067	0.049	49,119.5	48,194.7	49,554.8	5	76
ICRF J162418.4−680912......	1619−680	...	...		16 24 18.437150	−68 09 12.49811	0.000071	0.00057	−0.053	48,839.8	47,626.5	49,407.6	7	46
ICRF J162557.6+413440......	1624+416	3	2		16 25 57.669700	41 34 40.62922	0.000026	0.00031	−0.046	48,372.9	46,364.9	49,883.8	31	247
ICRF J163813.4+572023......	1637+574	...	...		16 38 13.456293	57 20 23.97918	0.000032	0.00027	−0.085	47,192.8	44,857.8	49,692.6	292	4339
ICRF J164207.8+685639......	1642+690	3	2		16 42 07.848514	68 56 39.75640	0.000050	0.00027	0.004	45,979.8	44,090.5	49,848.8	150	1899
ICRF J165801.4+344328......	1656+348	...	...		16 58 01.419204	34 43 28.40240	0.000048	0.00058	−0.393	49,385.0	48,853.8	49,883.8	5	56
ICRF J170734.4+014845......	1705+018	2	1		17 07 34.415277	01 48 45.69923	0.000019	0.00031	−0.103	49,323.7	48,194.7	49,883.8	30	296
ICRF J170934.3−172853......	1706−174	...	...		17 09 34.345380	−17 28 53.36480	0.000039	0.00056	−0.924	48,907.6	48,093.0	49,662.8	18	43
ICRF J172341.0−650036......	1718−649	...	...		17 23 41.029765	−65 00 36.61518	0.000092	0.00106	0.239	48,651.6	48,110.9	49,407.6	5	21
ICRF J172727.6+453039......	1726+455	2	1		17 27 27.650808	45 30 39.73139	0.000024	0.00026	−0.127	49,589.8	48,720.9	49,917.8	128	4185
ICRF J172818.6+501310......	1727+502	...	...		17 28 18.623853	50 13 10.47001	0.000140	0.00098	−0.188	48,540.1	47,459.8	49,576.9	9	39
ICRF J172824.9+042704......	1725+044	2	1		17 28 24.952716	04 27 04.91401	0.000020	0.00041	0.000	49,212.9	47,931.6	49,883.8	10	274
ICRF J174535.2+172001......	1743+173	2	1		17 45 35.208181	17 20 01.42341	0.000018	0.00030	−0.257	49,272.9	46,977.9	49,848.8	31	296
ICRF J174614.0+622654......	1745+624	1	2		17 46 14.034146	62 26 54.73842	0.000038	0.00027	−0.043	49,664.5	48,916.8	49,924.8	60	1609
ICRF J174832.8+700550......	1749+701	...	...		17 48 32.840231	70 05 50.76882	0.000077	0.00037	−0.025	47,325.4	44,203.7	49,924.8	16	210
ICRF J175322.6+440945......	1751+441	...	...		17 53 22.647901	44 09 45.68608	0.000032	0.00033	0.169	49,015.8	47,931.6	49,533.8	6	144
ICRF J180132.3+440421......	1800+440	...	...		18 01 32.314854	44 04 21.90031	0.000036	0.00046	0.115	48,687.0	48,194.7	49,659.8	8	71
ICRF J180323.4−650736......	1758−651	...	...	Y	18 03 23.496605	−65 07 36.76177	0.000085	0.00054	0.081	49,241.4	48,043.8	49,895.6	4	29
ICRF J182407.0+565101......	1823+568	1	1	Y	18 24 07.068372	56 51 01.49088	0.000033	0.00028	−0.047	48,232.8	45,138.8	49,750.8	92	703
ICRF J183250.1+283335......	1830+285	...	...		18 32 50.185631	28 33 35.95530	0.000035	0.00065	−0.283	48,734.8	48,357.8	49,659.8	7	50
ICRF J184208.9+794617......	1845+797	...	...		18 42 08.989953	79 46 17.12801	0.000137	0.00036	−0.399	48,610.5	44,203.7	49,659.8	15	161
ICRF J184233.6+680925......	1842+681	2	1		18 42 33.641636	68 09 25.22788	0.000061	0.00034	0.056	48,518.1	47,165.8	49,694.8	8	136
ICRF J184916.0+670541......	1849+670	1	2		18 49 16.072300	67 05 41.67993	0.000048	0.00028	−0.003	49,709.0	48,649.8	49,820.5	4	412
ICRF J185457.2+735119......	1856+737	...	...		18 54 57.299946	73 51 19.90747	0.000094	0.00043	0.276	48,602.2	47,011.4	49,667.9	8	101
ICRF J191240.0−801005......	1903−802	...	...		19 12 40.019176	−80 10 05.94627	0.000169	0.00041	0.004	48,421.5	47,626.5	48,865.8	5	26
ICRF J195542.7+513148......	1954+513	2	1		19 55 42.738273	51 31 48.54623	0.000028	0.00027	0.001	48,836.6	45,775.8	49,820.5	41	673
ICRF J195759.8−384506......	1954−388	...	...		19 57 59.819271	−38 45 06.35626	0.000025	0.00039	0.103	49,775.4	48,766.9	49,917.8	13	257
ICRF J200324.1−325145......	2000−330	...	...		20 03 24.116306	−32 51 45.13231	0.000040	0.00068	0.175	48,685.0	47,512.0	49,535.0	11	33
ICRF J201114.2−064403......	2008−068	...	...		20 11 14.215847	−06 44 03.55519	0.000050	0.00063	−0.838	49,068.6	48,346.0	49,662.8	13	29
ICRF J201713.0+744047......	2017+745	2	1		20 17 13.079311	74 40 47.99991	0.000072	0.00028	0.091	49,459.5	47,288.7	49,820.5	23	465
ICRF J202319.0+315302......	2021+317	3	1		20 23 19.017351	31 53 02.30595	0.000022	0.00031	0.091	48,563.6	45,775.8	49,611.9	22	215
ICRF J203147.9+545503......	2030+547	...	...		20 31 47.958562	54 55 03.14060	0.000042	0.00051	0.080	48,616.4	47,023.7	49,659.8	7	86
ICRF J203154.9+121941......	2029+121	3	1		20 31 54.994279	12 19 41.34043	0.000019	0.00034	0.073	48,966.6	47,019.9	49,848.8	14	230
ICRF J203837.0+511912......	2037+511	...	...		20 38 37.034755	51 19 12.66269	0.000028	0.00027	0.038	47,284.6	45,138.8	49,736.9	190	3063
ICRF J205051.1+312727......	2048+312	...	...		20 50 51.131502	31 27 27.37368	0.000108	0.00090	0.151	49,098.3	48,194.7	49,690.0	6	34
ICRF J205133.7+744140......	2051+745	...	...		20 51 33.734576	74 41 40.49823	0.000110	0.00038	−0.491	48,765.0	47,011.4	49,554.8	20	73
ICRF J205616.3−471447......	2052−474	...	...		20 56 16.359851	−47 14 47.62768	0.000033	0.00043	−0.139	49,285.7	48,162.4	49,911.8	15	104
ICRF J210138.8+034131......	2059+034	2	1		21 01 38.834187	03 41 31.32159	0.000026	0.00058	−0.033	48,629.7	48,434.7	49,533.8	4	74
ICRF J210544.9−782534......	2059−786	...	...		21 05 44.961453	−78 25 34.54664	0.000205	0.00058	0.030	48,784.8	47,626.5	49,895.6	7	24
ICRF J210933.1−411020......	2106−413	...	...		21 09 33.188582	−41 10 20.60530	0.000032	0.00042	−0.221	48,703.7	47,626.5	49,662.8	17	72
ICRF J211529.4+293338......	2113+293	1	1		21 15 29.413455	29 33 38.36694	0.000020	0.00028	−0.027	48,852.1	46,977.9	49,820.5	37	641
ICRF J211630.8−805355......	2109−811	...	...		21 16 30.845958	−80 53 55.22339	0.000180	0.00039	−0.020	49,328.3	48,043.8	49,895.6	9	66
ICRF J213901.3+142335......	2136+141	1	1		21 39 01.309267	14 23 35.99199	0.000018	0.00029	−0.042	48,861.8	45,466.3	49,848.8	22	351
ICRF J214622.9−152543......	2143−156	...	...		21 46 22.979340	−15 25 43.88526	0.000028	0.00044	−0.770	48,854.6	48,196.8	49,565.9	14	24
ICRF J214805.4+065738......	2145+067	2	2		21 48 05.458679	06 57 38.60422	0.000023	0.00026	0.000	48,939.7	44,773.8	49,924.8	1087	33641
ICRF J215203.1−780706......	2146−783	...	...		21 52 03.154504	−78 07 06.63962	0.000221	0.00063	0.316	48,577.3	47,626.5	49,330.5	7	29
ICRF J215224.8+173437......	2150+173	2	2		21 52 24.819405	17 34 37.79482	0.000020	0.00039	−0.028	48,516.6	47,005.8	49,456.8	23	150
ICRF J220743.7−534633......	2204−540	...	...		22 07 43.733296	−53 46 33.82004	0.000045	0.00056	0.016	48,786.5	48,110.9	49,790.7	6	27
ICRF J221205.9+235540......	2209+236	...	...		22 12 05.966318	23 55 40.54388	0.000023	0.00039	−0.031	48,674.5	48,194.7	49,848.8	9	141

TABLE 3—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	Epoch of Observation[d] First	Epoch of Observation[d] Last	N_{exp}[e]	N_{obs}[f]
ICRF J223036.4+694628......	2229+695	...	...		22 30 36.469725	69 46 28.07698	0.000071	0.00034	0.161	48,418.0	47,459.8	49,600.3	16	95
ICRF J223513.2−483558......	2232−488	...	...		22 35 13.236524	−48 35 58.79455	0.000049	0.00065	0.394	49,223.5	48,162.4	49,741.7	6	30
ICRF J225717.3+074312......	2254+074	...	...		22 57 17.303120	07 43 12.30284	0.000023	0.00052	−0.519	48,052.0	47,011.4	49,736.9	26	139
ICRF J231448.5−313839......	2312−319	...	...		23 14 48.500631	−31 38 39.52651	0.000050	0.00103	0.340	48,250.7	47,511.1	49,895.6	6	27
ICRF J232159.8+273246......	2319+272	3	1		23 21 59.862235	27 32 46.44343	0.000021	0.00033	0.020	49,197.7	47,023.7	49,820.5	21	321
ICRF J232225.9+505751......	2320+506	3	1		23 22 25.982159	50 57 51.96371	0.000041	0.00044	−0.011	49,021.5	48,720.9	49,498.8	2	44
ICRF J232917.7−473019......	2326−477	...	...		23 29 17.704369	−47 30 19.11519	0.000039	0.00053	0.264	48,341.4	47,305.8	49,629.6	31	138
ICRF J233138.6−155657......	2329−162	...	...		23 31 38.652436	−15 56 57.00952	0.000039	0.00051	0.012	48,859.0	47,176.5	49,650.8	2	25
ICRF J233159.4−381147......	2329−384	...	...		23 31 59.476115	−38 11 47.65053	0.000042	0.00066	0.095	48,273.4	47,640.2	49,895.6	5	22

[a] The ICRF designations were constructed from the J2000.0 coordinates with the format ICRF *JHHMMSS.s+DDMMSS* or ICRF *JHHMMSS.s−DDMMSS*. These designations follow the recommendations of the IAU Working Group on Designations.

Q1 [b] The IERS designations were previously constructed from the B1950.0 coordinates. The complete format including the acronym and the epoch, in addition to the coordinates, is IERS *BHHMM+DDd* or IERS *BHHMM−DDd*.

[c] X: structure index at the X band; S: structure index at the S band; H: a "Y" in this column indicates that the source served to link the *Hipparcos* stellar reference frame to the ICRS.

[d] The units are Modified Julian Date (i.e., JD − 2,400,000.5).

[e] The number of 24 hr experiments in which a source was observed.

[f] The number of pairs of delay and delay rate observations used in the astrometric solution.

TABLE 4

COORDINATES OF THE 294 CANDIDATE SOURCES IN THE ICRF

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha-\delta}$	Epoch of Observation[d] Mean	Epoch of Observation[d] First	Epoch of Observation[d] Last	N_{exp}[e]	N_{obs}[f]
ICRF J000435.6−473619......	0002−478	...	...		00 04 35.655596	−47 36 19.60356	0.000079	0.00097	0.019	49,435.5	49,330.5	49,524.7	3	7
ICRF J000613.8−062335......	0003−066	3	1		00 06 13.892887	−06 23 35.33485	0.000019	0.00034	−0.575	48,728.1	47,176.5	49,565.9	41	114
ICRF J001052.5−415310......	0008−421	...	...		00 10 52.519641	−41 53 10.78780	0.000652	0.00728	−0.548	48,551.8	48,162.4	49,330.5	2	6
ICRF J001101.2−261233......	0008−264	...	...		00 11 01.246752	−26 12 33.37686	0.000035	0.00040	−0.427	48,892.4	47,686.1	49,790.7	7	38
ICRF J001611.0−001512......	0013−005	...	...		00 16 11.088555	−00 15 12.44534	0.000020	0.00037	−0.675	48,920.3	47,394.1	49,611.9	27	116
ICRF J002442.9−420203......	0022−423	...	...		00 24 42.989850	−42 02 03.94978	0.000250	0.00222	−0.528	49,003.5	48,162.4	49,895.6	3	10
ICRF J003824.8+413706......	0035+413	...	...		00 38 24.843613	41 37 06.00069	0.000053	0.00066	−0.266	49,422.9	49,422.9	49,422.9	1	19
ICRF J005846.5−565911......	0056−572	...	...		00 58 46.581252	−56 59 11.47054	0.000084	0.00113	0.454	48,583.5	47,626.5	49,330.5	4	12
ICRF J005905.5+000651......	0056−001	4	3		00 59 05.514949	00 06 51.62203	0.000033	0.00093	0.304	49,186.6	47,005.8	49,659.8	11	173
ICRF J011137.3+390628......	0108+388	4	2		01 11 37.316975	39 06 28.10422	0.000030	0.00035	0.077	49,711.2	49,099.7	49,820.5	3	203
ICRF J011327.0+494824......	0110+495	...	...		01 13 27.006813	49 48 24.04351	0.000055	0.00060	−0.525	49,422.9	49,422.9	49,422.9	1	23
ICRF J011343.1+022217......	0111+021	...	...	Y	01 13 43.144954	02 22 17.31631	0.000023	0.00038	−0.822	48,461.2	47,023.7	49,667.9	28	160
ICRF J011517.0−012704......	0112−017	...	...		01 15 17.099966	−01 27 04.57725	0.000018	0.00031	−0.497	48,419.3	47,278.8	49,662.8	57	200
ICRF J011935.0+321050......	0116+319	4	4		01 19 35.000523	32 10 50.05410	0.001257	0.00806	0.231	49,284.0	48,787.9	49,820.5	4	10
ICRF J012031.6−270124......	0118−272	...	...		01 20 31.663311	−27 01 24.65133	0.000124	0.00112	−0.587	48,170.1	47,512.0	49,650.8	2	13
ICRF J012141.5+114950......	0119+115	2	1		01 21 41.595041	11 49 50.41319	0.000018	0.00030	−0.429	48,683.5	47,394.1	49,848.8	50	150
ICRF J012156.8+042224......	0119+041	2	1		01 21 56.861698	04 22 24.73438	0.000017	0.00026	0.412	48,822.9	46,977.9	49,911.8	1050	23707
ICRF J014922.3+055553......	0146+056	3	1		01 49 22.370918	05 55 53.56852	0.000022	0.00035	−0.691	48,208.1	47,288.7	49,736.9	23	107
ICRF J015002.6−072548......	0147−076	...	...		01 50 02.697551	−07 25 48.49067	0.000628	0.00580	−0.229	49,687.7	49,535.0	49,895.6	3	7
ICRF J015310.1−331025......	0150−334	...	...		01 53 10.121676	−33 10 25.86226	0.000063	0.00142	0.164	47,846.0	47,511.1	48,757.4	3	17
ICRF J015456.2+474326......	0151+474	...	...		01 54 56.289917	47 43 26.53907	0.000049	0.00046	0.002	49,750.8	49,750.8	49,750.8	1	36
ICRF J015537.0−404842......	0153−410	...	...		01 55 37.059396	−40 48 42.35592	0.000439	0.00283	−0.052	49,203.1	48,766.9	49,535.0	3	9
ICRF J020213.6−762003......	0202−765	...	...		02 02 13.694218	−76 20 03.05655	0.002733	0.00592	0.145	48,780.2	48,110.9	49,895.6	2	8
ICRF J020346.6+113445......	0201+113	2	1		02 03 46.657063	11 34 45.40956	0.000018	0.00027	−0.163	49,139.9	47,237.4	49,924.8	122	856
ICRF J020450.4+151411......	0202+149	2	2		02 04 50.413908	15 14 11.04337	0.000018	0.00026	0.194	49,004.4	45,997.8	49,924.8	238	4191
ICRF J020457.6−170119......	0202−172	...	...		02 04 57.674364	−17 01 19.84022	0.000031	0.00039	−0.097	48,904.2	47,171.5	49,790.7	6	72
ICRF J022428.4+065923......	0221+067	2	2		02 24 28.428183	06 59 23.34182	0.000019	0.00031	−0.653	48,789.9	47,394.1	49,662.8	35	77
ICRF J023145.8+132254......	0229+131	2	1		02 31 45.894055	13 22 54.71630	0.000017	0.00026	0.341	48,150.5	44,773.8	49,917.8	1314	35363
ICRF J023752.4+284808......	0234+285	3	2		02 37 52.405677	28 48 08.99008	0.000019	0.00026	0.160	47,723.9	44,447.0	49,904.8	1021	31420
ICRF J023945.4−023440......	0237−027	...	...		02 39 45.472273	−02 34 40.91378	0.000029	0.00077	−0.429	49,376.1	49,253.8	49,554.8	2	32
ICRF J023951.2+041621......	0237+040	2	1		02 39 51.263052	04 16 21.41185	0.000020	0.00036	−0.578	48,874.7	47,941.3	49,662.8	20	103
ICRF J024457.6+622806......	0241+622	...	...	Y	02 44 57.696828	62 28 06.51494	0.000425	0.00185	0.022	49,045.4	48,223.7	49,690.0	3	16
ICRF J025246.1−710435......	0252−712	...	...		02 52 46.156121	−71 04 35.27541	0.003779	0.02839	0.328	48,162.4	48,162.4	48,162.4	1	2
ICRF J025329.1−544151......	0252−549	...	...		02 53 29.180453	−54 41 51.43623	0.000055	0.00079	0.141	48,887.3	47,626.5	49,895.6	6	18
ICRF J025334.8+180542......	0250+178	...	...		02 53 34.882297	18 05 42.52378	0.002758	0.03513	−0.999	48,977.5	48,977.5	48,977.5	1	1
ICRF J030230.5+121856......	0259+121	3	1		03 02 30.546782	12 18 56.75084	0.009783	0.12252	−0.397	49,643.1	47,941.3	49,820.5	12	130
ICRF J030642.6+624302......	0302+625	2	1		03 06 42.659562	62 43 02.02420	0.000065	0.00058	−0.169	49,179.4	48,614.0	49,896.8	21	70
ICRF J031155.2−765150......	0312−770	...	...	Y	03 11 55.250335	−76 51 50.84843	0.000221	0.00067	0.476	48,768.1	48,110.9	49,895.6	3	17
ICRF J031951.2+190131......	0317+188	2	1		03 19 51.256736	19 01 31.29032	0.000028	0.00048	−0.737	49,377.6	48,942.5	49,662.8	9	20
ICRF J033553.9−543025......	0334−546	...	...		03 35 53.924919	−54 30 25.11446	0.000066	0.00137	0.211	48,994.3	47,626.5	49,650.8	5	13
ICRF J033717.1+013722......	0334+014	2	2		03 37 17.108822	01 37 22.74287	0.003043	0.01491	0.615	49,396.1	49,177.8	49,694.8	3	4
ICRF J033930.9−014635......	0336−019	2	1	Y	03 39 30.937785	−01 46 35.80391	0.000017	0.00026	0.337	49,437.7	44,773.8	49,924.8	303	7113
ICRF J034423.1+155943......	0341+158	2	1		03 44 23.172178	15 59 43.36987	0.000039	0.00132	−0.382	48,969.0	47,394.1	49,659.8	11	34
ICRF J035721.9−481215......	0355−483	...	...		03 57 21.917867	−48 12 15.16075	0.000092	0.00221	0.698	48,656.4	48,162.4	49,330.5	3	9
ICRF J040221.2−314725......	0400−319	...	...		04 02 21.266012	−31 47 25.94544	0.000044	0.00052	−0.361	49,318.6	48,766.9	49,482.7	4	27
ICRF J040659.0−382628......	0405−385	...	...		04 06 59.035298	−38 26 28.04070	0.000189	0.00122	−0.367	48,971.9	48,162.4	49,692.6	3	10
ICRF J040748.4−121136......	0405−123	...	...	Y	04 07 48.430971	−12 11 36.65948	0.000177	0.00123	−0.152	49,297.5	48,766.9	49,398.5	2	25
ICRF J040820.3−654509......	0407−658	...	...		04 08 20.380244	−65 45 09.07841	0.001072	0.00630	−0.236	48,507.8	48,162.4	48,766.9	2	7
ICRF J040905.7−123848......	0406−127	...	...		04 09 05.769741	−12 38 48.14414	0.000029	0.00044	−0.816	48,894.7	47,941.3	49,790.7	18	35
ICRF J042356.0+415002......	0420+417	...	...		04 23 56.009804	41 50 02.71305	0.000029	0.00035	0.233	48,365.2	47,568.6	49,694.8	18	173
ICRF J042747.5+045708......	0425+048	3	3		04 27 47.570443	04 57 08.32698	0.000111	0.01110	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 4—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	Epoch of Observation[d] First	Epoch of Observation[d] Last	$N_{\rm exp}$[e]	$N_{\rm obs}$[f]
ICRF J043221.1−510925......	0431−512	...	...		04 32 21.178158	−51 09 25.18839	0.000237	0.00323	0.864	48,510.0	48,043.8	49,895.6	3	7
ICRF J044017.1−433308......	0438−436	...	...		04 40 17.179991	−43 33 08.60397	0.000031	0.00038	−0.187	49,195.4	47,941.3	49,790.7	20	89
ICRF J044331.6+344106......	0440+345	2	1		04 43 31.635194	34 41 06.66403	0.000037	0.00047	−0.050	49,754.1	48,093.0	49,868.8	13	290
ICRF J044923.3+633209......	0444+634	...	...		04 49 23.310440	63 32 09.43451	0.000094	0.00066	−0.115	49,422.9	49,422.9	49,422.9	1	23
ICRF J045314.6−280737......	0451−282	...	...		04 53 14.646803	−28 07 37.32750	0.000100	0.00188	−0.694	48,761.9	47,176.5	49,398.5	9	41
ICRF J045550.7−461558......	0454−463	...	...		04 55 50.772475	−46 15 58.68148	0.000064	0.00271	−0.122	49,015.7	49,015.7	49,015.7	1	6
ICRF J050112.8−015914......	0458−020	2	1		05 01 12.809889	−01 59 14.25619	0.000017	0.00026	0.398	49,316.0	44,773.8	49,924.8	559	15943
ICRF J050215.4+060907......	0459+060	3	1		05 02 15.445934	06 09 07.49448	0.000034	0.00106	−0.339	49,685.6	47,394.1	49,820.5	6	94
ICRF J050401.7−604952......	0503−608	...	...		05 04 01.701356	−60 49 52.53773	0.000252	0.00138	0.520	48,563.7	48,110.9	49,330.5	3	12
ICRF J050927.4+101144......	0506+101	...	...		05 09 27.457073	10 11 44.60026	0.000065	0.00130	−0.654	48,909.0	47,394.1	49,736.9	28	63
ICRF J051349.1−215916......	0511−220	...	...		05 13 49.114333	−21 59 16.09208	0.000052	0.00140	−0.550	48,768.7	47,176.5	49,790.7	13	43
ICRF J051637.7−723707......	0517−726	...	...		05 16 37.719042	−72 37 07.46573	0.000622	0.00284	0.426	49,423.7	48,757.4	49,895.6	3	12
ICRF J052234.4−610757......	0522−611	...	...		05 22 34.425537	−61 07 57.13318	0.000069	0.00060	0.295	48,382.0	47,626.5	48,757.4	3	15
ICRF J052531.4−455754......	0524−460	...	...		05 25 31.400087	−45 57 54.68568	0.000125	0.00164	0.521	49,750.8	49,750.8	49,750.8	1	18
ICRF J053056.4+133155......	0528+134	1	1		05 30 56.416744	13 31 55.14954	0.000017	0.00026	0.277	48,026.8	44,773.8	49,924.8	1884	51914
ICRF J053238.9+073243......	0529+075	...	...		05 32 38.998447	07 32 43.34567	0.000105	0.00111	0.252	48,474.9	44,773.8	49,694.8	10	53
ICRF J053932.0−155030......	0537−158	...	...		05 39 32.010168	−15 50 30.32097	0.000051	0.00104	−0.716	48,283.7	47,941.3	49,031.1	7	9
ICRF J055530.8+394849......	0552+398	2	1		05 55 30.805608	39 48 49.16500	0.000022	0.00026	0.108	48,175.6	44,090.5	49,924.8	2343	118072
ICRF J060309.1+174216......	0600+177	2	1		06 03 09.130274	17 42 16.81064	0.000038	0.00111	−0.746	49,534.7	47,394.1	49,820.5	23	191
ICRF J060752.6+672055......	0602+673	...	...		06 07 52.671683	67 20 55.40986	0.000078	0.00043	−0.096	49,750.8	49,750.8	49,750.8	1	37
ICRF J060759.6−083449......	0605−085	...	...		06 07 59.699234	−08 34 49.97806	0.000019	0.00033	−0.423	47,995.7	44,773.8	49,750.8	31	149
ICRF J060940.9−154240......	0607−157	...	...		06 09 40.949516	−15 42 40.67238	0.000049	0.00140	−0.443	49,047.1	45,466.3	49,790.7	19	89
ICRF J061357.6+130645......	0611+131	...	...		06 13 57.692754	13 06 45.40144	0.000047	0.00117	−0.529	48,945.9	47,394.1	49,667.9	9	27
ICRF J061635.9−345616......	0614−349	...	...		06 16 35.981345	−34 56 16.56410	0.005405	0.03903	−0.947	48,766.9	48,766.9	48,766.9	1	2
ICRF J061732.3−363414......	0615−365	...	...		06 17 32.323936	−36 34 14.80314	0.004648	0.04163	−0.969	48,766.9	48,766.9	48,766.9	1	3
ICRF J062331.7−441302......	0622−441	...	...		06 23 31.786306	−44 13 02.54171	0.000640	0.00450	−0.068	48,162.4	48,162.4	48,162.4	1	5
ICRF J062419.0+385648......	0620+389	...	...		06 24 19.021315	38 56 48.73591	0.000025	0.00033	−0.016	49,631.0	49,391.7	49,690.0	6	112
ICRF J063920.9−334600......	0637−337	...	...		06 39 20.904728	−33 46 00.11360	0.000095	0.00117	0.168	47,782.3	47,511.1	48,865.8	3	10
ICRF J064524.0+212151......	0642+214	...	...		06 45 24.099488	21 21 51.20191	0.000034	0.00054	−0.878	49,125.6	48,093.0	49,662.8	15	43
ICRF J064814.0−304419......	0646−306	2	2		06 48 14.096463	−30 44 19.65964	0.000035	0.00041	−0.601	49,131.7	47,640.2	49,662.8	8	145
ICRF J064848.4−473427......	0647−475	...	...		06 48 48.452021	−47 34 27.18600	0.005321	0.02110	−0.739	48,766.9	48,766.9	48,766.9	1	2
ICRF J065358.2+370540......	0650+371	...	...		06 53 58.282844	37 05 40.60649	0.000035	0.00052	−0.227	49,030.1	48,348.6	49,750.8	37	113
ICRF J070001.5+170921......	0657+172	2	1		07 00 01.525540	17 09 21.70163	0.000018	0.00027	−0.026	48,854.1	47,517.4	49,692.6	113	849
ICRF J070134.5−463436......	0700−465	...	...		07 01 34.547145	−46 34 36.62034	0.000469	0.00392	−0.332	48,162.4	48,162.4	48,162.4	1	3
ICRF J072905.4−363945......	0727−365	...	...		07 29 05.425027	−36 39 45.29030	0.054838	0.28833	−0.999	48,766.9	48,766.9	48,766.9	1	1
ICRF J073816.9−332212......	0736−332	...	...		07 38 16.949145	−33 22 12.77740	0.000305	0.00193	−0.452	49,082.7	48,766.9	49,398.5	2	8
ICRF J073918.0+013704......	0736+017	...	...		07 39 18.033894	01 37 04.61797	0.000020	0.00035	−0.560	47,553.9	44,773.8	49,600.3	26	130
ICRF J074202.7+490015......	0738+491	...	...		07 42 02.748951	49 00 15.60912	0.000042	0.00039	−0.096	49,750.8	49,750.8	49,750.8	1	34
ICRF J074331.6−672625......	0743−673	...	...		07 43 31.611506	−67 26 25.54618	0.001087	0.06235	−0.185	48,600.5	48,110.9	49,535.0	4	17
ICRF J075052.0+123104......	0748+126	...	...		07 50 52.045731	12 31 04.82823	0.000019	0.00030	−0.154	47,761.5	44,773.8	49,662.8	19	239
ICRF J080815.5−075109......	0805−077	3	1		08 08 15.536036	−07 51 09.88642	0.000019	0.00032	−0.459	48,618.6	47,176.5	49,790.7	27	95
ICRF J081108.8−492943......	0809−493	...	...		08 11 08.802530	−49 29 43.50928	0.000722	0.00539	−0.152	48,043.8	48,043.8	48,043.8	1	5
ICRF J081126.7+014652......	0808+019	1	1		08 11 26.707322	01 46 52.21998	0.000018	0.00031	−0.317	49,268.6	46,977.9	49,820.5	29	279
ICRF J081815.9+422245......	0814+425	...	...		08 18 15.999611	42 22 45.41498	0.000024	0.00027	0.029	48,208.8	45,138.8	49,690.0	137	1496
ICRF J082526.8−501038......	0823−500	...	...		08 25 26.869117	−50 10 38.48735	0.000227	0.00148	−0.399	48,784.2	48,162.4	49,895.6	3	21
ICRF J082538.6+615728......	0821+621	...	...		08 25 38.612165	61 57 28.57917	0.000111	0.00050	0.293	49,422.9	49,422.9	49,422.9	1	28
ICRF J082550.3+030924......	0823+033	2	1		08 25 50.338356	03 09 24.52016	0.000017	0.00026	0.123	49,199.7	45,466.3	49,911.8	408	11767
ICRF J082601.5−223027......	0823−223	...	...		08 26 01.572952	−22 30 27.20373	0.000123	0.00278	−0.556	47,023.6	46,875.8	47,171.5	2	12
ICRF J083052.0+241059......	0827+243	...	...		08 30 52.086191	24 10 59.82068	0.000023	0.00037	0.003	48,238.8	47,023.7	49,611.9	11	123
ICRF J083322.3−444138......	0831−445	...	...		08 33 22.315631	−44 41 38.71463	0.000603	0.00381	−0.254	49,027.6	48,043.8	49,895.6	6	15
ICRF J083520.6−451035......	0833−450	...	...		08 35 20.655289	−45 10 35.15391	0.001715	0.01125	−0.395	48,132.8	48,043.8	48,162.4	2	4
ICRF J084124.3+705342......	0836+710	...	...		08 41 24.365236	70 53 42.17328	0.000117	0.00064	0.140	48,387.6	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 4—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	Epoch of Observation[d] First	Epoch of Observation[d] Last	N_{exp}[e]	N_{obs}[f]
ICRF J084127.0−754027......	0842−754	...	...		08 41 27.034888	−75 40 27.87078	0.002953	0.00740	−0.514	48,205.3	48,110.9	48,865.8	2	8
ICRF J085448.8+200630......	0851+202	2	1	Y	08 54 48.874924	20 06 30.64088	0.000018	0.00026	0.086	47,708.7	44,203.7	49,924.8	2173	64014
ICRF J090216.8−141530......	0859−140	...	...		09 02 16.830898	−14 15 30.87530	0.000042	0.00044	−0.560	48,495.2	46,875.8	49,600.3	20	70
ICRF J090910.0+012135......	0906+015	...	...		09 09 10.091601	01 21 35.61770	0.000020	0.00035	−0.422	48,304.1	47,005.8	49,750.8	22	186
ICRF J091437.9+024559......	0912+029	...	...		09 14 37.913439	02 45 59.24629	0.000072	0.00109	−0.898	48,863.7	47,407.6	49,554.8	4	13
ICRF J092246.4−395935......	0920−397	...	...		09 22 46.418275	−39 59 35.06753	0.000035	0.00075	−0.471	49,064.5	47,686.1	49,911.8	20	90
ICRF J092314.4+384939......	0920+390	...	...		09 23 14.452940	38 49 39.91017	0.000025	0.00032	−0.134	49,847.9	49,736.9	49,910.8	11	110
ICRF J092751.8−203451......	0925−203	...	...		09 27 51.824304	−20 34 51.23227	0.000091	0.00626	−0.526	48,662.3	47,941.3	49,517.3	24	68
ICRF J093032.5−853359......	0936−853	...	...		09 30 32.571196	−85 33 59.69200	0.004016	0.00396	0.068	48,887.3	48,162.4	49,650.8	4	15
ICRF J095524.7+690113......	0951+692	...	...		09 55 24.774751	69 01 13.70255	0.000107	0.00065	0.123	49,238.5	49,225.8	49,267.8	3	97
ICRF J100159.9−443800......	0959−443	...	...		10 01 59.907283	−44 38 00.60564	0.000549	0.00411	−0.490	48,506.8	48,043.8	49,895.6	2	8
ICRF J100614.0−501813......	1004−500	...	...		10 06 14.009559	−50 18 13.47089	0.001635	0.01727	−0.887	49,535.0	49,535.0	49,535.0	1	2
ICRF J101353.4+244916......	1011+250	...	...		10 13 53.428730	24 49 16.44127	0.000038	0.00069	−0.276	49,233.4	48,353.6	49,694.8	17	42
ICRF J101725.8+611627......	1014+615	...	...		10 17 25.887530	61 16 27.49687	0.000085	0.00053	0.199	49,422.9	49,422.9	49,422.9	1	34
ICRF J102232.7−103744......	1020−103	...	...	Y	10 22 32.798030	−10 37 44.38842	0.007404	0.02425	0.877	49,650.8	49,650.8	49,650.8	1	2
ICRF J102444.8+191220......	1022+194	2	2		10 24 44.809595	19 12 20.41526	0.000047	0.00099	−0.218	49,688.4	47,783.2	49,820.5	8	175
ICRF J103507.0+562846......	1031+567	...	...	Y	10 35 07.040181	56 28 46.79673	0.000209	0.00185	0.562	48,462.2	47,023.7	49,690.0	15	95
ICRF J104142.9−474006......	1039−474	...	...		10 41 42.939703	−47 40 06.52738	0.029517	0.28851	−1.000	49,535.0	49,535.0	49,535.0	1	1
ICRF J104455.9+065538......	1042+071	...	...		10 44 55.911265	06 55 38.26250	0.000035	0.00069	−0.504	48,909.9	47,783.2	49,498.8	5	19
ICRF J104827.6+714335......	1044+719	1	1		10 48 27.619892	71 43 35.93846	0.000056	0.00026	0.024	49,651.6	47,605.1	49,909.6	108	4169
ICRF J105104.7−313814......	1048−313	...	...		10 51 04.777555	−31 38 14.30773	0.000069	0.00058	−0.228	47,671.5	47,640.2	47,686.1	2	22
ICRF J105653.6+701145......	1053+704	...	...		10 56 53.617499	70 11 45.91587	0.000057	0.00029	−0.010	49,462.0	49,125.7	49,883.8	17	246
ICRF J110331.5−325116......	1101−325	...	...	Y	11 03 31.526414	−32 51 16.69195	0.000064	0.00183	0.297	48,815.6	47,511.1	49,650.8	5	7
ICRF J110352.2−535700......	1101−536	...	...		11 03 52.221670	−53 57 00.69643	0.000033	0.00033	0.134	49,235.8	47,626.5	49,895.6	25	181
ICRF J110427.3+381231......	1101+384	1	1	Y	11 04 27.313906	38 12 31.79908	0.000039	0.00052	0.557	49,668.7	49,519.8	49,690.0	2	32
ICRF J110712.6−682050......	1105−680	...	...		11 07 12.694528	−68 20 50.72894	0.000304	0.00163	0.640	48,934.7	48,388.4	49,330.5	3	19
ICRF J111826.9−463415......	1116−462	...	...		11 18 26.957601	−46 34 15.00140	0.000062	0.00082	0.491	48,556.1	48,110.9	49,330.5	6	16
ICRF J112027.8+142054......	1117+146	3	4		11 20 27.807269	14 20 54.99422	0.000538	0.00710	−0.454	49,207.4	49,098.6	49,533.8	2	4
ICRF J112704.3−185717......	1124−186	...	...		11 27 04.392428	−18 57 17.44154	0.000019	0.00030	−0.208	49,242.7	46,875.8	49,911.8	91	684
ICRF J112813.3+592514......	1125+596	...	...		11 28 13.340725	59 25 14.80002	0.000118	0.00076	0.263	49,422.9	49,422.9	49,422.9	1	27
ICRF J113007.0−144927......	1127−145	4	2		11 30 07.052573	−14 49 27.38793	0.000037	0.00114	−0.351	49,312.6	45,259.2	49,790.7	26	352
ICRF J113130.5−050019......	1128−047	...	...		11 31 30.516713	−05 00 19.65713	0.000031	0.00061	−0.087	49,408.6	49,099.7	49,547.8	4	48
ICRF J113143.2−581853......	1129−580	...	...		11 31 43.287417	−58 18 53.44656	0.001192	0.01188	0.805	49,535.0	49,535.0	49,535.0	1	2
ICRF J114701.3−381211......	1144−379	...	...		11 47 01.370687	−38 12 11.02348	0.000024	0.00030	−0.328	49,308.2	47,654.0	49,924.8	64	314
ICRF J114751.5−072441......	1145−071	3	1		11 47 51.554038	−07 24 41.14107	0.000018	0.00029	−0.045	49,194.8	47,176.5	49,819.8	56	464
ICRF J115043.8−002354......	1148−001	...	...		11 50 43.870784	−00 23 54.20485	0.000024	0.00056	0.089	48,127.8	47,023.7	49,848.8	17	128
ICRF J115912.7−094052......	1156−094	3	3		11 59 12.711697	−09 40 52.04888	0.000079	0.00322	−0.773	49,323.1	47,941.3	49,790.7	8	17
ICRF J115931.8+291443......	1156+295	2	2		11 59 31.833914	29 14 43.82693	0.000020	0.00026	−0.071	48,185.2	46,977.9	49,848.8	285	7176
ICRF J120935.2−401613......	1206−399	...	...		12 09 35.243318	−40 16 13.10027	0.018417	0.02742	0.244	47,807.2	47,511.1	48,043.8	3	9
ICRF J121546.7−173145......	1213−172	...	...		12 15 46.751764	−17 31 45.40287	0.000043	0.00041	0.004	48,762.4	46,840.8	49,868.8	4	34
ICRF J121806.2−460029......	1215−457	...	...		12 18 06.252147	−46 00 29.01041	0.001021	0.00776	−0.811	48,746.5	48,162.4	49,330.5	2	6
ICRF J122131.6+281358......	1219+285	...	...		12 21 31.690512	28 13 58.50014	0.000023	0.00034	−0.495	46,621.3	44,447.0	49,848.8	27	203
ICRF J122452.4+033050......	1222+037	...	...		12 24 52.421888	03 30 50.29322	0.000053	0.00195	−0.032	48,144.4	46,502.8	49,576.9	47	185
ICRF J122454.3−831310......	1221−829	...	...		12 24 54.383445	−83 13 10.10523	0.003023	0.00611	−0.493	48,043.8	48,043.8	48,043.8	1	4
ICRF J123049.4+122328......	1228+126	3	2		12 30 49.423381	12 23 28.04390	0.000034	0.00047	−0.057	49,380.5	46,502.8	49,924.8	40	457
ICRF J123715.2−504623......	1234−504	...	...		12 37 15.238939	−50 46 23.17192	0.001450	0.00627	−0.679	48,766.9	48,766.9	48,766.9	1	6
ICRF J123943.0−102328......	1237−101	...	...		12 39 43.061423	−10 23 28.69259	0.000043	0.00064	0.221	49,398.5	49,398.5	49,398.5	1	8
ICRF J123959.4−113722......	1237−113	...	...		12 39 59.430198	−11 37 22.98492	0.001402	0.01335	−0.675	49,889.7	49,883.8	49,895.6	2	4
ICRF J124251.3+375100......	1240+381	...	...		12 42 51.369079	37 51 00.02510	0.000051	0.00042	−0.316	49,534.2	49,429.9	49,750.8	2	80
ICRF J124604.2−073046......	1243−072	...	...		12 46 04.232116	−07 30 46.57478	0.000027	0.00046	−0.578	47,836.0	47,176.5	49,498.8	11	40
ICRF J124646.8−254749......	1244−255	...	...		12 46 46.802038	−25 47 49.28871	0.000020	0.00029	−0.299	49,085.4	46,875.8	49,895.6	87	557
ICRF J125359.5−405930......	1251−407	...	...		12 53 59.533598	−40 59 30.68936	0.000171	0.00503	0.543	49,814.0	49,650.8	49,895.6	[illegible]	[illegible]

TABLE 4—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	Epoch of Observation[d] First	Epoch of Observation[d] Last	$N_{\rm exp}$[e]	$N_{\rm obs}$[f]
ICRF J125614.2+565225......	1254+571	...	...	Y	12 56 14.233964	56 52 25.23721	0.000105	0.00096	0.656	49,690.0	49,690.0	49,690.0	1	24
ICRF J125759.0−315516......	1255−316	...	...		12 57 59.060767	−31 55 16.85182	0.000025	0.00041	0.220	49,500.7	47,640.2	49,911.8	13	208
ICRF J130533.0−103319......	1302−102	...	...	Y	13 05 33.015018	−10 33 19.42796	0.000020	0.00033	−0.481	48,565.2	47,176.5	49,600.3	25	78
ICRF J130933.9+115424......	1307+121	3	2		13 09 33.932424	11 54 24.55204	0.000044	0.00076	0.098	49,705.3	49,099.7	49,820.5	3	137
ICRF J131607.9−333859......	1313−333	1	1		13 16 07.985934	−33 38 59.17236	0.000024	0.00031	−0.466	49,069.2	47,415.7	49,692.6	67	322
ICRF J131736.4+342515......	1315+346	2	1	Y	13 17 36.494181	34 25 15.93257	0.000025	0.00049	−0.464	49,169.7	47,946.4	49,690.0	21	88
ICRF J132304.2−445233......	1320−446	...	...		13 23 04.245804	−44 52 33.85272	0.000623	0.00321	0.149	49,065.5	48,766.9	49,895.6	3	17
ICRF J132527.6−430108......	1322−427	...	...		13 25 27.615217	−43 01 08.80528	0.000198	0.00161	0.732	49,205.8	48,110.9	49,895.6	3	14
ICRF J132616.5+315409......	1323+321	4	4		13 26 16.511396	31 54 09.51991	0.000188	0.00199	0.028	49,398.8	48,223.7	49,542.2	6	110
ICRF J133108.2+303032......	1328+307	...	...		13 31 08.288145	30 30 32.95986	0.000094	0.00119	0.442	49,095.9	48,787.9	49,498.8	4	25
ICRF J133237.5−664650......	1329−665	...	...		13 32 37.517448	−66 46 50.44682	0.092072	0.94670	0.979	48,766.9	48,766.9	48,766.9	1	1
ICRF J133752.4−650924......	1334−649	...	...		13 37 52.444609	−65 09 24.89757	0.000798	0.00335	−0.259	48,969.7	48,043.8	49,895.6	2	10
ICRF J134022.9+375443......	1338+381	...	...	Y	13 40 22.951763	37 54 43.83468	0.000111	0.00120	−0.483	49,287.4	49,031.1	49,848.8	7	29
ICRF J134733.3+121724......	1345+125	4	4		13 47 33.361635	12 17 24.24023	0.000028	0.00064	0.032	49,297.5	47,659.7	49,542.2	9	187
ICRF J135256.5−441240......	1349−439	...	...		13 52 56.534909	−44 12 40.38741	0.000038	0.00066	−0.548	48,911.6	48,110.9	49,692.6	16	49
ICRF J135406.8−020603......	1351−018	...	...		13 54 06.895314	−02 06 03.19053	0.000018	0.00030	0.023	49,625.3	48,573.8	49,910.8	38	417
ICRF J135546.6−632642......	1352−632	...	...		13 55 46.611660	−63 26 42.57485	0.000518	0.00349	0.265	49,573.6	49,535.0	49,650.8	2	6
ICRF J135711.2−152728......	1354−152	...	...		13 57 11.244965	−15 27 28.78636	0.000020	0.00031	−0.512	48,251.4	46,875.8	49,662.8	91	309
ICRF J135755.3+764321......	1357+769	1	1		13 57 55.371524	76 43 21.05116	0.000076	0.00026	−0.068	49,585.2	47,011.4	49,924.8	178	17427
ICRF J135900.1−415252......	1355−416	...	...		13 59 00.183255	−41 52 52.63210	0.001757	0.01158	−0.393	48,110.9	48,110.9	48,110.9	1	4
ICRF J140445.8−013021......	1402−012	...	...		14 04 45.895486	−01 30 21.94945	0.000122	0.00160	0.297	49,287.6	48,664.8	49,690.0	6	34
ICRF J140501.1+041535......	1402+044	2	1		14 05 01.119805	04 15 35.81906	0.000018	0.00031	−0.212	49,589.6	48,888.7	49,883.8	33	322
ICRF J140856.4−075226......	1406−076	...	...		14 08 56.481199	−07 52 26.66622	0.000041	0.00043	−0.673	48,701.5	47,176.5	49,790.7	22	58
ICRF J141154.8+213423......	1409+218	...	...		14 11 54.862136	21 34 23.43722	0.000076	0.00209	−0.406	49,001.4	48,863.2	49,498.8	2	23
ICRF J141946.6+382148......	1417+385	...	...		14 19 46.613740	38 21 48.47498	0.000050	0.00054	−0.193	49,750.8	49,750.8	49,750.8	1	30
ICRF J141959.2+270625......	1417+273	...	...		14 19 59.297083	27 06 25.55244	0.000070	0.00166	−0.455	48,930.3	48,863.2	49,533.8	2	30
ICRF J142230.3+322310......	1420+326	...	...		14 22 30.379016	32 23 10.43924	0.000082	0.00579	−0.568	49,086.8	48,863.2	49,533.8	2	9
ICRF J142700.3+234800......	1424+240	...	...	Y	14 27 00.391837	23 48 00.03493	0.000073	0.00149	−0.500	48,914.2	48,863.2	49,554.8	3	40
ICRF J143257.6−180135......	1430−178	...	...		14 32 57.690619	−18 01 35.24845	0.000059	0.00445	−0.897	48,767.6	48,160.3	49,565.9	13	23
ICRF J143439.7+195200......	1432+200	2	1		14 34 39.793350	19 52 00.73552	0.000141	0.00099	0.016	49,740.0	48,863.2	49,820.5	3	169
ICRF J143535.4+301224......	1433+304	2	1		14 35 35.402170	30 12 24.51975	0.000173	0.00211	0.168	48,926.8	48,863.2	49,498.8	2	10
ICRF J143809.4−220454......	1435−218	...	...		14 38 09.469411	−22 04 54.74790	0.000081	0.00069	−0.746	48,901.4	47,176.5	49,445.6	23	60
ICRF J144553.3−162901......	1443−162	...	...		14 45 53.376319	−16 29 01.61908	0.000032	0.00046	−0.872	48,583.9	47,941.3	49,565.9	13	29
ICRF J145427.4−374733......	1451−375	...	...		14 54 27.409777	−37 47 33.14437	0.000029	0.00047	−0.010	48,839.4	47,511.1	49,650.8	12	60
ICRF J145432.9−401232......	1451−400	...	...		14 54 32.912346	−40 12 32.51446	0.000029	0.00037	−0.050	49,399.3	47,640.2	49,895.6	14	108
ICRF J150506.4+032630......	1502+036	...	...		15 05 06.477205	03 26 30.81298	0.000032	0.00075	−0.180	49,101.0	48,853.8	49,554.8	3	49
ICRF J150704.7−165230......	1504−166	...	...		15 07 04.786942	−16 52 30.26722	0.000021	0.00032	−0.659	48,398.5	46,840.8	49,694.8	39	122
ICRF J151002.9+570243......	1508+572	...	...		15 10 02.922371	57 02 43.37606	0.000035	0.00030	−0.067	49,715.9	49,541.8	49,917.8	8	213
ICRF J151344.8−101200......	1511−100	...	...		15 13 44.893455	−10 12 00.26452	0.000024	0.00038	−0.685	48,337.8	46,875.8	49,611.9	23	68
ICRF J151741.8−242219......	1514−241	...	...	Y	15 17 41.813134	−24 22 19.47579	0.000026	0.00035	−0.702	48,400.4	46,840.8	49,565.9	20	59
ICRF J152237.6−273010......	1519−273	...	...		15 22 37.675993	−27 30 10.78535	0.000020	0.00029	−0.206	49,033.8	46,875.8	49,895.6	119	531
ICRF J154929.4+023701......	1546+027	2	1		15 49 29.436848	02 37 01.16336	0.000018	0.00032	−0.362	49,030.9	47,005.8	49,848.8	29	240
ICRF J155059.1−825806......	1540−828	...	...		15 50 59.144724	−82 58 06.84194	0.004432	0.00508	0.149	48,779.1	48,043.8	49,330.5	2	7
ICRF J155751.4−000150......	1555+001	...	...		15 57 51.433965	−00 01 50.41366	0.000018	0.00030	−0.570	48,287.7	44,773.8	49,659.8	62	235
ICRF J155821.9−140959......	1555−140	...	...		15 58 21.949635	−14 09 59.07210	0.001209	0.01638	−0.999	48,833.4	48,704.1	48,977.5	4	4
ICRF J155930.9+030448......	1557+032	...	...		15 59 30.972613	03 04 48.25682	0.000029	0.00040	−0.133	49,678.0	49,541.8	49,883.8	7	91
ICRF J160140.4+431647......	1600+432	...	...		16 01 40.443935	43 16 47.75702	0.000164	0.00210	−0.012	49,883.8	49,883.8	49,883.8	1	5
ICRF J160140.5+431646......	1600+431	...	...		16 01 40.515432	43 16 46.47617	0.000161	0.00471	0.292	49,883.8	49,883.8	49,883.8	1	3
ICRF J160431.0−444131......	1600−445	...	...		16 04 31.020029	−44 41 31.95353	0.042414	0.65519	0.999	49,535.0	49,535.0	49,535.0	1	1
ICRF J161341.0+341247......	1611+343	3	1	Y	16 13 41.064250	34 12 47.90905	0.000021	0.00026	−0.216	48,648.8	44,773.8	49,924.8	834	27514
ICRF J161637.5+045932......	1614+051	...	...		16 16 37.556818	04 59 32.73653	0.000018	0.00030	−0.154	49,199.1	47,605.1	49,904.8	41	296
ICRF J162606.0−295126......	1622−297	...	...		16 26 06.020829	−29 51 26.97074	0.000029	0.00038	−0.613	48,640.5	46,840.8	49,917.8	[illegible]	[illegible]

TABLE 4—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	Epoch of Observation[d] First	Epoch of Observation[d] Last	N_{exp}[e]	N_{obs}[f]
ICRF J165039.5−294346......	1647−296	...	...		16 50 39.544133	−29 43 46.95469	0.000072	0.00082	−0.958	48,973.9	48,346.0	49,662.8	13	17
ICRF J165352.2+394536......	1652+398	3	2	Y	16 53 52.216693	39 45 36.60877	0.000023	0.00029	−0.029	49,018.2	45,997.8	49,910.8	25	420
ICRF J165802.7+473749......	1656+477	...	...		16 58 02.779637	47 37 49.23143	0.000044	0.00045	0.000	49,234.0	49,184.9	49,498.8	2	32
ICRF J165809.0+074127......	1655+077	...	...		16 58 09.011473	07 41 27.54050	0.000021	0.00037	−0.387	48,578.9	47,407.6	49,659.8	15	96
ICRF J165833.4+051516......	1656+053	...	...		16 58 33.447346	05 15 16.44429	0.000018	0.00031	−0.089	48,005.3	44,773.8	49,429.9	41	584
ICRF J170053.1−261051......	1657−261	...	...		17 00 53.154046	−26 10 51.72492	0.000024	0.00033	−0.620	48,238.6	46,875.8	49,662.8	36	123
ICRF J170717.7+453610......	1705+456	3	2		17 07 17.753406	45 36 10.55272	0.000069	0.00077	−0.079	49,682.5	48,434.7	49,820.5	6	183
ICRF J173315.1−372232......	1729−373	...	...		17 33 15.192721	−37 22 32.39565	0.000550	0.00354	−0.335	49,650.8	49,650.8	49,650.8	1	2
ICRF J173420.5+385751......	1732+389	...	...		17 34 20.578531	38 57 51.44298	0.000023	0.00029	−0.174	48,576.0	46,977.9	49,600.3	43	257
ICRF J173549.0+504911......	1734+508	...	...		17 35 49.005166	50 49 11.56586	0.000037	0.00042	0.219	49,429.9	49,429.9	49,429.9	1	87
ICRF J173735.7−563403......	1733−565	...	...		17 37 35.770462	−56 34 03.15477	0.000665	0.00430	0.887	49,173.5	48,388.4	49,330.5	2	6
ICRF J173927.3+495503......	1738+499	...	...		17 39 27.390512	49 55 03.36831	0.000039	0.00037	−0.118	49,590.6	49,422.9	49,750.8	3	92
ICRF J173957.1+473758......	1738+476	2	1		17 39 57.129064	47 37 58.36131	0.000031	0.00034	0.176	48,364.5	47,288.7	49,848.8	13	135
ICRF J174036.9+521143......	1739+522	2	1		17 40 36.977847	52 11 43.40753	0.000028	0.00026	−0.104	48,846.4	47,165.8	49,909.6	1006	58894
ICRF J174425.4−514443......	1740−517	...	...		17 44 25.450704	−51 44 43.79284	0.000633	0.00373	0.627	48,766.9	48,766.9	48,766.9	1	5
ICRF J174726.6+465850......	1746+470	...	...		17 47 26.647300	46 58 50.92630	0.000036	0.00037	−0.231	49,596.3	49,422.9	49,750.8	3	89
ICRF J175132.8+093900......	1749+096	1	1		17 51 32.818576	09 39 00.72846	0.000017	0.00026	−0.436	48,923.8	44,447.0	49,924.8	825	20158
ICRF J175151.2−252400......	1748−253	...	...		17 51 51.263054	−25 24 00.06011	0.000470	0.00503	0.230	48,802.3	48,110.9	49,098.6	2	10
ICRF J180024.7+384830......	1758+388	...	...		18 00 24.765360	38 48 30.69771	0.000024	0.00029	−0.052	49,570.0	49,429.9	49,826.8	4	157
ICRF J180045.6+782804......	1803+784	2	1	Y	18 00 45.683911	78 28 04.01854	0.000087	0.00026	−0.027	47,884.0	45,138.8	49,917.8	1620	68029
ICRF J180650.6+694928......	1807+698	...	...		18 06 50.680653	69 49 28.10859	0.000052	0.00027	0.032	48,181.8	45,997.8	49,882.8	50	423
ICRF J180821.8+454220......	1806+456	...	...		18 08 21.885910	45 42 20.86644	0.000034	0.00040	−0.338	49,495.4	49,422.9	49,547.8	2	50
ICRF J180957.8−455241......	1806−458	...	...		18 09 57.871831	−45 52 41.01367	0.000485	0.00233	−0.565	49,629.6	49,629.6	49,629.6	1	2
ICRF J181935.0−634548......	1814−637	...	...		18 19 35.002525	−63 45 48.19427	0.000794	0.00851	−0.293	49,277.1	48,162.4	49,895.6	3	12
ICRF J182057.8−252812......	1817−254	...	...		18 20 57.848684	−25 28 12.58397	0.000119	0.00104	−0.117	49,362.8	48,804.9	49,833.8	4	24
ICRF J182402.8+104423......	1821+107	3	1		18 24 02.855269	10 44 23.77392	0.000020	0.00036	−0.156	48,819.1	45,466.3	49,790.7	20	341
ICRF J183537.2−714958......	1829−718	...	...		18 35 37.205091	−71 49 58.21900	0.001166	0.00475	0.412	48,766.9	48,766.9	48,766.9	1	7
ICRF J183728.7−710843......	1831−711	...	...		18 37 28.714952	−71 08 43.55453	0.000064	0.00033	−0.004	48,850.0	47,626.5	49,692.6	17	189
ICRF J191109.6−200655......	1908−201	...	...		19 11 09.652867	−20 06 55.10860	0.000030	0.00091	−0.623	48,874.2	46,840.8	49,790.7	41	153
ICRF J192332.1−210433......	1920−211	...	...		19 23 32.189804	−21 04 33.33284	0.000024	0.00035	−0.724	48,637.7	47,407.6	49,662.8	40	92
ICRF J192559.6+210626......	1923+210	...	...		19 25 59.605374	21 06 26.16209	0.000019	0.00028	−0.197	48,372.8	45,138.8	49,662.8	109	665
ICRF J192840.8+084848......	1926+087	...	...		19 28 40.855498	08 48 48.41260	0.000075	0.00258	0.041	49,678.3	49,541.8	49,690.0	3	29
ICRF J193006.1−605609......	1925−610	...	...		19 30 06.160015	−60 56 09.18402	0.000082	0.00098	−0.157	48,438.5	47,626.5	49,330.5	5	18
ICRF J193124.9+224331......	1929+226	1	1		19 31 24.916786	22 43 31.25884	0.000029	0.00050	−0.149	49,755.2	48,614.0	49,904.8	9	256
ICRF J193435.0+104340......	1932+106	...	...		19 34 35.025577	10 43 40.36503	0.000050	0.00173	−0.310	49,690.0	49,690.0	49,690.0	1	22
ICRF J193510.4+203154......	1932+204	1	1		19 35 10.472891	20 31 54.15344	0.000041	0.00137	0.232	49,168.1	48,804.9	49,554.8	5	22
ICRF J193716.2−395801......	1933−400	...	...		19 37 16.217368	−39 58 01.55290	0.000034	0.00046	−0.604	48,596.7	47,640.2	49,662.8	23	85
ICRF J193925.0−634245......	1934−638	...	...		19 39 25.026661	−63 42 45.62554	0.000430	0.00187	−0.214	48,963.3	48,766.9	49,650.8	2	9
ICRF J193926.6−152543......	1936−155	...	...		19 39 26.657726	−15 25 43.05792	0.000029	0.00108	−0.839	48,722.5	47,176.5	49,662.8	22	62
ICRF J193957.2−100241......	1937−101	...	...		19 39 57.256570	−10 02 41.52067	0.000027	0.00096	−0.215	49,357.5	48,110.9	49,650.8	5	77
ICRF J194121.7−621121......	1936−623	...	...		19 41 21.768473	−62 11 21.05558	0.000753	0.00583	−0.331	48,162.4	48,162.4	48,162.4	1	5
ICRF J194606.2+230004......	1943+228	...	...		19 46 06.251939	23 00 04.41107	0.000518	0.00620	−0.408	48,861.0	48,797.8	48,919.9	3	10
ICRF J195330.8+353759......	1951+355	2	1		19 53 30.875733	35 37 59.36071	0.000073	0.00207	0.554	49,144.8	48,919.9	49,533.8	3	32
ICRF J195740.5+333827......	1955+335	...	...	Y	19 57 40.550036	33 38 27.94555	0.000099	0.00148	−0.429	49,163.8	49,098.6	49,554.8	2	21
ICRF J200925.3−484953......	2005−489	...	...	Y	20 09 25.390729	−48 49 53.72128	0.000643	0.00737	0.369	48,833.8	47,626.5	49,750.8	7	36
ICRF J202510.8+334300......	2023+335	3	3		20 25 10.842102	33 43 00.21600	0.000142	0.00193	−0.454	48,976.5	48,223.7	49,667.9	4	27
ICRF J204008.7−250746......	2037−253	...	...		20 40 08.772845	−25 07 46.66253	0.000060	0.00056	−0.420	48,666.1	47,686.1	49,650.8	3	18
ICRF J205741.6−373402......	2054−377	...	...		20 57 41.603472	−37 34 02.98978	0.000258	0.00195	−0.426	49,089.5	48,162.4	49,398.5	2	12
ICRF J210159.1−421916......	2058−425	...	...		21 01 59.114188	−42 19 16.16206	0.000936	0.00935	0.669	49,017.6	48,162.4	49,895.6	4	11
ICRF J210217.0+470216......	2100+468	...	...	Y	21 02 17.056050	47 02 16.25468	0.000181	0.00193	0.186	49,467.2	49,177.8	49,690.0	3	10
ICRF J211810.5−301911......	2115−305	...	...		21 18 10.597647	−30 19 11.60596	0.000236	0.00247	−0.741	48,904.1	48,162.4	49,398.5	2	5
ICRF J212912.1−153841......	2126−158	...	...		21 29 12.175895	−15 38 41.04054	0.000020	0.00033	−0.242	49,109.4	47,176.5	[illegible]	[illegible]	[illegible]

TABLE 4—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	Epoch of Observation[d] First	Epoch of Observation[d] Last	N_{exp}[e]	N_{obs}[f]
ICRF J213410.3−015317......	2131−021	2	1		21 34 10.309614	−01 53 17.23883	0.000018	0.00030	−0.537	48,519.0	47,176.5	49,736.9	56	195
ICRF J214710.1+092946......	2144+092	...	...		21 47 10.162975	09 29 46.67236	0.000020	0.00032	−0.284	47,658.1	45,997.8	49,848.8	23	321
ICRF J214712.7−753613......	2142−758	...	...		21 47 12.730293	−75 36 13.22513	0.000192	0.00060	0.280	48,289.6	47,626.5	48,749.6	4	14
ICRF J215137.8+055212......	2149+056	...	...		21 51 37.875502	05 52 12.95459	0.000021	0.00034	−0.662	48,377.8	45,466.3	49,662.8	23	125
ICRF J215705.9−694123......	2152−699	...	...		21 57 05.980566	−69 41 23.68553	0.000212	0.00132	0.780	48,509.0	48,110.9	49,330.5	3	11
ICRF J215852.0−301332......	2155−304	...	...		21 58 52.065068	−30 13 32.11840	0.000354	0.00191	−0.376	49,253.6	48,766.9	49,895.6	3	14
ICRF J221302.4−252930......	2210−257	...	...		22 13 02.498009	−25 29 30.08140	0.000084	0.00201	−0.400	48,701.6	46,875.8	49,694.8	3	13
ICRF J221438.5−383545......	2211−388	...	...		22 14 38.569326	−38 35 45.01022	0.000564	0.00353	0.160	49,127.8	48,766.9	49,398.5	2	7
ICRF J221620.0+351814......	2214+350	...	...		22 16 20.009936	35 18 14.18072	0.000051	0.00080	−0.197	49,750.8	49,750.8	49,750.8	1	28
ICRF J222547.2−045701......	2223−052	...	...		22 25 47.259294	−04 57 01.39048	0.000019	0.00061	−0.646	48,183.0	44,773.8	49,736.9	34	111
ICRF J222940.0−083254......	2227−088	1	1		22 29 40.084339	−08 32 54.43530	0.000018	0.00062	−0.309	49,215.2	45,466.3	49,820.5	37	208
ICRF J223040.2−394252......	2227−399	...	...		22 30 40.278611	−39 42 52.06692	0.000053	0.00106	0.510	48,896.9	48,162.4	49,895.6	4	16
ICRF J223622.4+282857......	2234+282	2	1		22 36 22.470868	28 28 57.41338	0.000019	0.00026	0.100	48,611.2	45,725.8	49,924.8	1125	34156
ICRF J223634.0−143322......	2233−148	...	...		22 36 34.087158	−14 33 22.18931	0.000055	0.00062	−0.694	48,636.1	47,176.5	49,662.8	16	32
ICRF J224838.6−323552......	2245−328	...	...		22 48 38.685719	−32 35 52.18748	0.000073	0.00161	−0.795	48,728.9	47,394.1	49,662.8	26	85
ICRF J225504.2−084404......	2252−090	3	3		22 55 04.239777	−08 44 04.02151	0.000057	0.00234	−0.619	49,610.8	47,394.1	49,820.5	17	137
ICRF J225536.7+420252......	2253+417	...	...		22 55 36.707842	42 02 52.53256	0.000027	0.00031	−0.146	48,127.3	47,005.8	49,662.8	46	266
ICRF J225717.5+024317......	2254+024	1	1		22 57 17.563086	02 43 17.51193	0.000022	0.00050	−0.679	48,809.9	47,394.1	49,848.8	22	122
ICRF J230223.8−371806......	2259−375	...	...		23 02 23.888469	−37 18 06.84027	0.008831	0.06321	−0.434	48,746.5	48,162.4	49,330.5	2	2
ICRF J230305.8−303011......	2300−307	...	...		23 03 05.821287	−30 30 11.47289	0.021640	0.03255	0.246	48,368.5	48,110.9	49,398.5	2	5
ICRF J230343.5−680737......	2300−683	...	...	Y	23 03 43.565673	−68 07 37.45706	0.035391	0.45061	−0.999	49,650.8	49,650.8	49,650.8	1	1
ICRF J231409.3−445549......	2311−452	...	...		23 14 09.382823	−44 55 49.23782	0.000320	0.00259	0.111	48,863.3	48,162.4	49,330.5	2	10
ICRF J232044.8+051349......	2318+049	...	...		23 20 44.856618	05 13 49.95245	0.000019	0.00032	−0.606	48,446.7	47,019.9	49,667.9	35	166
ICRF J232331.9−031705......	2320−035	...	...		23 23 31.953753	−03 17 05.02363	0.000018	0.00040	−0.552	48,886.2	47,394.1	49,736.9	54	193
ICRF J232747.9−144755......	2325−150	...	...		23 27 47.964255	−14 47 55.75021	0.000051	0.00102	0.302	48,034.2	47,176.5	49,535.0	2	11
ICRF J233040.8+110018......	2328+107	...	...		23 30 40.852252	11 00 18.70971	0.000020	0.00032	−0.498	48,250.9	46,977.9	49,611.9	27	157
ICRF J233355.2−234340......	2331−240	...	...		23 33 55.237802	−23 43 40.65782	0.000080	0.00233	−0.773	48,803.8	46,875.8	49,398.5	25	67
ICRF J233612.1−523621......	2333−528	...	...		23 36 12.144624	−52 36 21.94997	0.000534	0.00372	0.468	48,579.6	48,110.9	49,573.6	3	9
ICRF J233757.3−023057......	2335−027	3	1		23 37 57.339083	−02 30 57.62923	0.000096	0.00784	−0.716	48,729.9	47,941.3	49,600.3	24	40
ICRF J234636.8+093045......	2344+092	...	...		23 46 36.838560	09 30 45.51493	0.000020	0.00032	−0.458	48,573.6	47,288.7	49,667.9	25	122
ICRF J235430.1−151311......	2351−154	...	...		23 54 30.195186	−15 13 11.21285	0.000103	0.00538	−0.675	48,664.2	47,394.1	49,694.8	31	62
ICRF J235600.6−682003......	2353−686	...	...		23 56 00.681458	−68 20 03.47158	0.000103	0.00056	−0.012	48,560.7	48,162.4	48,757.4	3	17
ICRF J235753.2−531113......	2355−534	...	...		23 57 53.266123	−53 11 13.68933	0.000040	0.00048	0.180	48,516.8	47,626.5	49,790.7	18	81
ICRF J235810.8−102008......	2355−106	...	...		23 58 10.882414	−10 20 08.61132	0.000018	0.00028	−0.261	48,848.8	47,394.1	49,883.8	134	616
ICRF J235933.1+385042......	2356+385	...	...		23 59 33.180777	38 50 42.31796	0.000085	0.00144	−0.282	49,519.8	49,519.8	49,519.8	1	4

[a] The ICRF designations were constructed from the J2000.0 coordinates with the format ICRF *JHHMMSS.s+DDMMSS* or ICRF *JHHMMSS.s−DDMMSS*. These designations follow the recommendations of the IAU Working Group on Designations.

[b] The IERS designations were previously constructed from the B1950.0 coordinates. The complete format including the acronym and the epoch, in addition to the coordinates, is IERS *BHHMM+DDd* or IERS *BHHMM−DDd*.

[c] X: structure index at the X band; S: structure index at the S band; H: a "Y" in this column indicates that the source served to link the *Hipparcos* stellar reference frame to the ICRS.

[d] The units are Modified Julian Date (i.e., JD − 2,400,000.5).

[e] The number of 24 hr experiments in which a source was observed.

[f] The number of pairs of delay and delay rate observations used in the astrometric solution.

TABLE 5

COORDINATES OF THE 102 "OTHER" SOURCES IN THE ICRF

Designation[a]	Source[b]	Note[c] X	S	H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	First	Last	N_{exp}[e]	N_{obs}[f]
ICRF J001945.7+732730......	0016+731	2	1		00 19 45.786433	73 27 30.01751	0.000093	0.00039	...	48,894.7	47,165.8	49,750.8	411	21652
ICRF J002232.4+060804......	0019+058	...	...		00 22 32.441263	06 08 04.26943	0.000172	0.00351	...	49,127.9	47,394.1	49,790.7	18	51
ICRF J002914.2+345632......	0026+346	4	4		00 29 14.242502	34 56 32.24702	0.000312	0.00248	...	49,382.7	47,011.4	49,820.5	12	201
ICRF J005041.3−092905......	0048−097	1	1		00 50 41.317392	−09 29 05.21022	0.000037	0.00090	...	49,249.2	44,773.8	49,924.8	374	9641
ICRF J010245.7+582411......	0059+581	2	1		01 02 45.762387	58 24 11.13669	0.000046	0.00038	...	49,501.0	48,720.9	49,924.8	244	31138
ICRF J010645.1−403419......	0104−408	...	...		01 06 45.107969	−40 34 19.96036	0.000150	0.00259	...	49,399.7	47,511.1	49,917.8	116	719
ICRF J010838.7+013500......	0106+013	...	...		01 08 38.771070	01 35 00.31714	0.000079	0.00214	...	46,746.8	44,447.0	49,897.8	1204	24158
ICRF J011612.5−113615......	0113−118	...	...		01 16 12.521959	−11 36 15.43371	0.000103	0.00293	...	48,898.9	47,176.5	49,600.3	28	92
ICRF J013741.2+330935......	0134+329	...	...	Y	01 37 41.299454	33 09 35.13378	0.000194	0.00650	...	48,597.5	48,194.7	49,667.9	10	64
ICRF J021046.2−510101......	0208−512	...	...		02 10 46.200412	−51 01 01.89187	0.000105	0.00128	...	49,152.9	47,305.8	49,911.8	166	1871
ICRF J021730.8+734932......	0212+735	2	2		02 17 30.813365	73 49 32.62180	0.000118	0.00049	...	47,445.3	44,857.8	49,600.3	1304	42970
ICRF J024008.1−230915......	0237−233	4	3		02 40 08.174536	−23 09 15.73288	0.000407	0.00752	...	49,347.5	48,126.7	49,662.8	19	244
ICRF J024104.7−081520......	0238−084	4	2		02 41 04.798520	−08 15 20.75174	0.000056	0.00290	...	49,625.2	47,176.5	49,917.8	38	378
ICRF J030335.2+471616......	0300+470	2	1		03 03 35.242225	47 16 16.27549	0.000047	0.00057	...	48,144.6	45,138.8	49,736.9	736	23188
ICRF J031948.1+413042......	0316+413	...	...	Y	03 19 48.160106	41 30 42.10328	0.000182	0.00380	...	46,427.5	44,090.5	49,751.9	195	5784
ICRF J032153.1+122113......	0319+121	...	...		03 21 53.103501	12 21 13.95380	0.000068	0.00148	...	48,586.6	47,019.9	49,790.7	12	144
ICRF J032957.6+275615......	0326+277	...	...	Y	03 29 57.669425	27 56 15.49901	0.000138	0.00210	...	48,673.3	47,165.8	49,694.8	24	108
ICRF J033413.6−400825......	0332−403	...	...		03 34 13.654484	−40 08 25.39779	0.000142	0.00163	...	48,667.0	47,640.2	49,790.7	15	72
ICRF J033630.1+321829......	0333+321	...	...		03 36 30.107611	32 18 29.34237	0.000068	0.00117	...	48,549.1	44,773.8	49,576.9	73	424
ICRF J034035.6−211931......	0338−214	...	...		03 40 35.607839	−21 19 31.17150	0.000097	0.00072	...	48,292.6	46,875.8	49,629.6	4	34
ICRF J035929.7+505750......	0355+508	...	...		03 59 29.747263	50 57 50.16149	0.000146	0.00142	...	46,522.7	44,090.5	49,771.8	509	14647
ICRF J040353.7−360501......	0402−362	...	...		04 03 53.749905	−36 05 01.91299	0.000142	0.00247	...	48,953.0	47,415.7	49,924.8	104	445
ICRF J040534.0−130813......	0403−132	...	...		04 05 34.003421	−13 08 13.69129	0.000052	0.00149	...	48,959.3	47,176.5	49,650.8	3	43
ICRF J040820.3+303230......	0405+304	...	...	Y	04 08 20.377574	30 32 30.49043	0.000201	0.00512	...	49,508.6	49,177.8	49,690.0	8	56
ICRF J042315.8−012033......	0420−014	3	1	Y	04 23 15.800726	−01 20 33.06524	0.000051	0.00116	...	48,071.3	44,773.8	49,895.6	1289	28507
ICRF J043311.0+052115......	0430+052	4	3	Y	04 33 11.095560	05 21 15.61961	0.000117	0.00261	...	46,766.3	44,090.5	49,542.2	51	679
ICRF J043701.4−184448......	0434−188	...	...		04 37 01.482726	−18 44 48.61337	0.000095	0.00212	...	48,633.6	46,875.8	49,861.8	120	478
ICRF J045703.1−232452......	0454−234	2	1		04 57 03.179223	−23 24 52.01989	0.000065	0.00158	...	48,881.0	46,440.9	49,924.8	1090	15911
ICRF J050321.1+020304......	0500+019	...	...		05 03 21.197194	02 03 04.67555	0.000097	0.00328	...	48,702.4	47,394.1	49,848.8	13	92
ICRF J053007.9−250329......	0528−250	...	...		05 30 07.962815	−25 03 29.89975	0.000113	0.00122	...	48,755.0	47,512.0	49,650.8	12	72
ICRF J053850.3−440508......	0537−441	3	1	Y	05 38 50.361540	−44 05 08.93895	0.000126	0.00216	...	49,238.2	47,305.8	49,911.8	266	2098
ICRF J053942.3+143345......	0536+145	1	1		05 39 42.365997	14 33 45.56181	0.000061	0.00286	...	48,975.3	47,605.1	49,667.9	32	78
ICRF J071338.1+434917......	0710+439	4	3		07 13 38.164136	43 49 17.20702	0.000120	0.00272	...	49,264.0	48,179.7	49,611.9	23	307
ICRF J071424.8+353439......	0711+356	...	...		07 14 24.817575	35 34 39.79350	0.000131	0.00223	...	48,238.8	45,466.3	49,667.9	13	131
ICRF J073019.1−114112......	0727−115	2	1		07 30 19.112468	−11 41 12.60041	0.000043	0.00105	...	48,776.5	45,259.2	49,924.8	1384	32167
ICRF J073807.3+174218......	0735+178	...	...	Y	07 38 07.393745	17 42 18.99829	0.000039	0.00056	...	49,065.8	44,773.8	49,750.8	503	12686
ICRF J074533.0+101112......	0742+103	4	1		07 45 33.059509	10 11 12.69254	0.000049	0.00108	...	48,006.6	44,773.8	49,820.5	316	6712
ICRF J074554.0−004417......	0743−006	2	1		07 45 54.082299	−00 44 17.53921	0.000105	0.00284	...	47,387.2	45,997.8	49,694.8	25	198
ICRF J092129.3−261843......	0919−260	3	2		09 21 29.353871	−26 18 43.38615	0.000128	0.00339	...	49,223.8	46,840.8	49,911.8	187	2389
ICRF J092703.0+390220......	0923+392	2	1		09 27 03.013906	39 02 20.85196	0.000042	0.00047	...	48,039.2	44,090.5	49,924.8	2185	96427
ICRF J095533.1+690355......	0951+693	...	...		09 55 33.173011	69 03 55.06104	0.000215	0.00089	...	49,464.9	49,141.8	49,917.8	10	397
ICRF J095649.8+251516......	0953+254	2	1		09 56 49.875356	25 15 16.04963	0.000043	0.00060	...	49,232.2	44,447.0	49,909.6	250	5878
ICRF J100741.4+135629......	1004+141	3	2		10 07 41.498082	13 56 29.60073	0.000050	0.00104	...	49,254.9	47,011.4	49,904.8	21	317
ICRF J102429.5−005255......	1021−006	...	...		10 24 29.586611	−00 52 55.49786	0.000119	0.00244	...	49,253.9	48,664.8	49,690.0	9	97
ICRF J103716.0−293402......	1034−293	1	1		10 37 16.079728	−29 34 02.81318	0.000107	0.00242	...	48,768.6	46,440.9	49,911.8	620	5639
ICRF J104806.6−190935......	1045−188	...	...		10 48 06.620574	−19 09 35.72656	0.000084	0.00173	...	48,683.5	47,176.5	49,629.6	3	18
ICRF J105829.6+013358......	1055+018	...	...		10 58 29.605209	01 33 58.82372	0.000052	0.00182	...	47,703.2	44,773.8	49,662.8	266	4021

TABLE 5—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	First	Last	N_{exp}[e]	N_{obs}[f]
ICRF J110708.6−444907......	1104−445	...	...		11 07 08.694143	−44 49 07.61841	0.000152	0.00247	...	49,113.9	47,626.5	49,911.8	216	1478
ICRF J112553.7+261019......	1123+264	...	...		11 25 53.711931	26 10 19.97862	0.000067	0.00112	...	48,715.5	46,977.9	49,848.8	147	1120
ICRF J114658.2+395834......	1144+402	...	...		11 46 58.297906	39 58 34.30461	0.000078	0.00116	...	47,065.9	45,138.8	49,662.8	138	2084
ICRF J122906.6+020308......	1226+023	...	...	Y	12 29 06.699728	02 03 08.59824	0.000119	0.00284	...	46,610.7	44,090.5	49,751.9	1120	27264
ICRF J125611.1−054721......	1253−055	...	...		12 56 11.166507	−05 47 21.52481	0.000111	0.00300	...	47,337.9	44,090.5	49,882.8	242	4321
ICRF J130252.4+574837......	1300+580	1	1		13 02 52.465276	57 48 37.60941	0.000069	0.00075	...	49,830.6	49,422.9	49,897.8	14	874
ICRF J133739.7−125724......	1334−127	2	1		13 37 39.782777	−12 57 24.69308	0.000054	0.00130	...	48,947.4	46,840.8	49,924.8	1080	23245
ICRF J135704.4+191907......	1354+195	...	...		13 57 04.436658	19 19 07.37228	0.000057	0.00131	...	47,372.1	44,447.0	49,692.6	103	1482
ICRF J140700.3+282714......	1404+286	3	1	Y	14 07 00.394410	28 27 14.68993	0.000051	0.00111	...	47,270.8	44,342.2	49,694.8	1180	33641
ICRF J141558.8+132023......	1413+135	1	3		14 15 58.817491	13 20 23.71254	0.000088	0.00260	...	48,463.5	45,138.8	49,848.8	29	107
ICRF J142756.2−420619......	1424−418	...	...		14 27 56.297557	−42 06 19.43749	0.000165	0.00285	...	48,891.8	47,305.8	49,909.6	182	934
ICRF J145907.5+714019......	1458+718	3	3		14 59 07.583954	71 40 19.86799	0.000188	0.00092	...	49,543.4	48,194.7	49,820.5	10	417
ICRF J150424.9+102939......	1502+106	2	1		15 04 24.979782	10 29 39.19865	0.000050	0.00137	...	48,080.2	44,447.0	49,662.8	603	12485
ICRF J151250.5−090559......	1510−089	3	1		15 12 50.532937	−09 05 59.82948	0.000064	0.00181	...	48,546.6	44,773.8	49,895.6	312	3756
ICRF J155035.2+052710......	1548+056	...	...		15 50 35.269244	05 27 10.44822	0.000046	0.00103	...	47,546.1	44,773.8	49,692.6	258	5739
ICRF J160913.3+264129......	1607+268	4	4		16 09 13.320772	26 41 29.03661	0.000091	0.00206	...	49,315.3	44,090.5	49,820.5	10	247
ICRF J161749.2−771718......	1610−771	...	...		16 17 49.276341	−77 17 18.46743	0.000239	0.00092	...	49,185.0	47,626.5	49,911.8	144	1849
ICRF J162546.8−252738......	1622−253	1	1		16 25 46.891640	−25 27 38.32671	0.000081	0.00205	...	48,907.5	46,840.8	49,924.8	750	10193
ICRF J163515.4+380804......	1633+382	3	1		16 35 15.492972	38 08 04.50061	0.000061	0.00069	...	47,914.7	44,447.0	49,924.8	456	13175
ICRF J164029.6+394646......	1638+398	1	1		16 40 29.632774	39 46 46.02854	0.000031	0.00039	...	49,368.5	45,322.5	49,924.8	233	14985
ICRF J164258.8+394836......	1641+399	...	...	Y	16 42 58.809950	39 48 36.99399	0.000091	0.00104	...	46,595.1	44,090.5	49,771.8	1145	42754
ICRF J171913.0+174506......	1717+178	...	...		17 19 13.048474	17 45 06.43699	0.000065	0.00147	...	48,244.5	47,011.4	49,667.9	12	133
ICRF J173302.7−130449......	1730−130	...	...		17 33 02.705785	−13 04 49.54820	0.000089	0.00250	...	47,500.6	45,259.2	49,924.8	624	14448
ICRF J174358.8−035004......	1741−038	1	1		17 43 58.856142	−03 50 04.61667	0.000037	0.00084	...	48,671.3	44,773.8	49,924.8	1467	41345
ICRF J175342.4+284804......	1751+288	2	1		17 53 42.473634	28 48 04.93913	0.000066	0.00147	...	49,206.3	47,005.8	49,848.8	22	244
ICRF J181945.3−552120......	1815−553	...	...		18 19 45.399520	−55 21 20.74557	0.000198	0.00196	...	48,756.8	47,626.5	49,911.8	74	554
ICRF J182314.1+793849......	1826+796	4	2		18 23 14.108739	79 38 49.00270	0.000383	0.00122	...	49,348.0	47,019.9	49,542.2	20	403
ICRF J190255.9+315941......	1901+319	...	...		19 02 55.938891	31 59 41.70211	0.000070	0.00114	...	49,072.8	48,103.5	49,756.8	19	190
ICRF J192451.0−291430......	1921−293	2	1		19 24 51.055959	−29 14 30.12084	0.000084	0.00217	...	48,425.1	45,259.2	49,917.8	899	15705
ICRF J192748.4+735801......	1928+738	...	...		19 27 48.495214	73 58 01.56997	0.000181	0.00081	...	48,080.8	44,772.8	49,611.9	116	944
ICRF J194025.5−690756......	1935−692	...	...		19 40 25.528136	−69 07 56.97209	0.000340	0.00189	...	48,972.8	47,626.5	49,895.6	10	36
ICRF J195510.7−611519......	1950−613	...	...		19 55 10.770607	−61 15 19.14003	0.000792	0.00365	...	49,048.7	48,766.9	49,330.5	2	12
ICRF J200057.0−174857......	1958−179	1	1		20 00 57.090449	−17 48 57.67236	0.000069	0.00185	...	49,067.1	46,875.8	49,911.8	591	7567
ICRF J200530.9+775243......	2007+777	3	1		20 05 30.998513	77 52 43.24766	0.000146	0.00039	...	49,097.1	45,997.8	49,694.8	235	11430
ICRF J200617.6+642445......	2005+642	...	...		20 06 17.694616	64 24 45.41805	0.000133	0.00035	...	49,573.8	49,422.9	49,798.8	3	52
ICRF J200744.9+402948......	2005+403	...	...		20 07 44.944909	40 29 48.60472	0.000355	0.00489	...	48,064.0	44,773.8	49,667.9	8	46
ICRF J201115.7−154640......	2008−159	...	...		20 11 15.710887	−15 46 40.25296	0.000144	0.00507	...	48,225.6	46,840.8	49,662.8	35	83
ICRF J202206.6+613658......	2021+614	4	3		20 22 06.681695	61 36 58.80479	0.000123	0.00124	...	49,304.3	47,165.8	49,600.3	27	658
ICRF J212344.5+053522......	2121+053	2	1		21 23 44.517381	05 35 22.09321	0.000063	0.00110	...	47,948.5	44,773.8	49,909.6	657	18823
ICRF J213032.8+050217......	2128+048	...	...		21 30 32.877495	05 02 17.47450	0.000268	0.00328	...	48,208.4	47,288.7	49,554.8	22	79
ICRF J213135.2−120704......	2128−123	3	2	Y	21 31 35.261752	−12 07 04.79583	0.000068	0.00168	...	48,886.9	45,466.3	49,924.8	462	4897
ICRF J213638.5+004154......	2134+004	4	1		21 36 38.586304	00 41 54.21353	0.000115	0.00333	...	46,731.8	44,090.5	49,897.8	884	18282
ICRF J215155.5−302753......	2149−307	...	...		21 51 55.524002	−30 27 53.69786	0.000078	0.00154	...	48,434.1	47,640.2	49,020.5	12	61
ICRF J215806.2−150109......	2155−152	...	...		21 58 06.281926	−15 01 09.32725	0.000186	0.00303	...	47,917.2	46,835.8	49,600.3	37	130
ICRF J220243.2+421639......	2200+420	3	1	Y	22 02 43.291381	42 16 39.97998	0.000066	0.00087	...	46,736.2	44,090.5	49,883.8	839	21824
ICRF J220314.9+314538......	2201+315	3	1	Y	22 03 14.975796	31 45 38.27004	0.000034	0.00053	...	49,110.2	45,492.6	49,883.8	188	7996
ICRF J221852.0−033536......	2216−038	3	1	Y	22 18 52.037725	−03 35 36.87944	0.000056	0.00152	...	47,624.5	44,773.8	49,848.8	449	9472

TABLE 5—*Continued*

Designation[a]	Source[b]	Note[c] X	Note[c] S	Note[c] H	α (J2000.0)	δ (J2000.0)	σ_α (s)	σ_δ (arcsec)	$C_{\alpha\text{-}\delta}$	Epoch of Observation[d] Mean	Epoch of Observation[d] First	Epoch of Observation[d] Last	N_{exp}[e]	N_{obs}[f]
ICRF J223236.4+114350......	2230+114	4	2		22 32 36.408913	11 43 50.90434	0.000079	0.00202	...	48,000.6	45,997.8	49,662.8	165	1315
ICRF J224618.2−120651......	2243−123	...	...		22 46 18.231969	−12 06 51.27684	0.000051	0.00124	...	49,115.0	44,773.8	49,924.8	133	930
ICRF J225357.7+160853......	2251+158	...	...	Y	22 53 57.747938	16 08 53.56088	0.000079	0.00137	...	46,700.1	44,090.5	49,848.8	1121	30988
ICRF J225805.9−275821......	2255−282	1	2		22 58 05.962888	−27 58 21.25659	0.000088	0.00240	...	48,869.9	46,875.8	49,911.8	662	7579
ICRF J234029.0+264156......	2337+264	4	3	Y	23 40 29.029471	26 41 56.80428	0.000095	0.00106	...	49,388.4	48,357.8	49,848.8	10	363
ICRF J234802.6−163112......	2345−167	...	...		23 48 02.608517	−16 31 12.02167	0.000139	0.00287	...	47,712.9	46,440.9	49,662.8	153	849
ICRF J235421.6+455304......	2351+456	...	...	Y	23 54 21.680275	45 53 04.23669	0.000096	0.00127	...	48,370.1	47,011.4	49,662.8	29	172
ICRF J235509.4+495008......	2352+495	...	...		23 55 09.458164	49 50 08.34014	0.000208	0.00262	...	48,116.3	47,019.9	49,659.8	14	140

[a] The ICRF designations were constructed from the J2000.0 coordinates with the format: ICRF *JHHMMSS.s+DDMMSS* or ICRF *JHHMMSS.s−DDMMSS*. These designations follow the recommendations of the IAU Working Group on Designations.

[b] The IERS designations were previously constructed from the B1950.0 coordinates. The complete format including the acronym and the epoch, in addition to the coordinates, is IERS *BHHMM+DDd* or IERS *BHHMM−DDd*.

[c] X: structure index at the X band; S: structure index at the S band; H: a "Y" in this column indicates that the source served to link the *Hipparcos* stellar reference frame to the ICRS.

[d] The units are Modified Julian Date (i.e., JD − 2,400,000.5).

[e] The number of 24 hr experiments in which a source was observed.

[f] The number of pairs of delay and delay rate observations used in the astrometric solution.

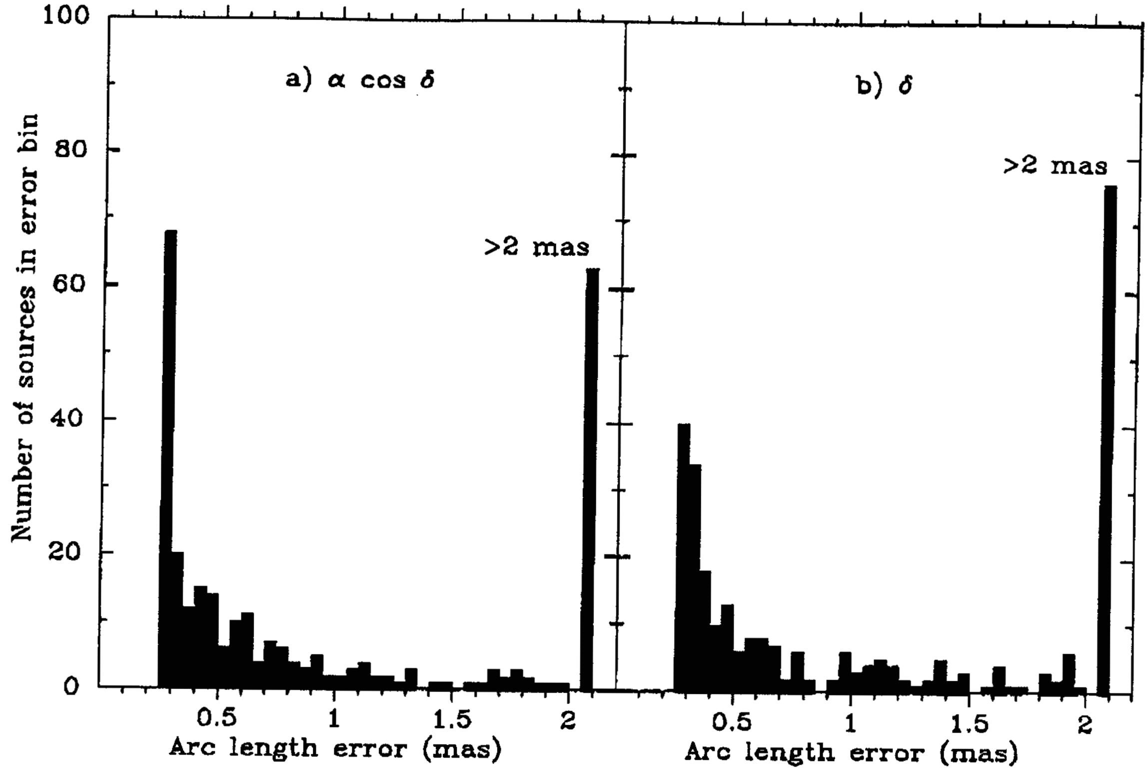

FIG. 7.—Same as Fig. 6, but for candidate sources

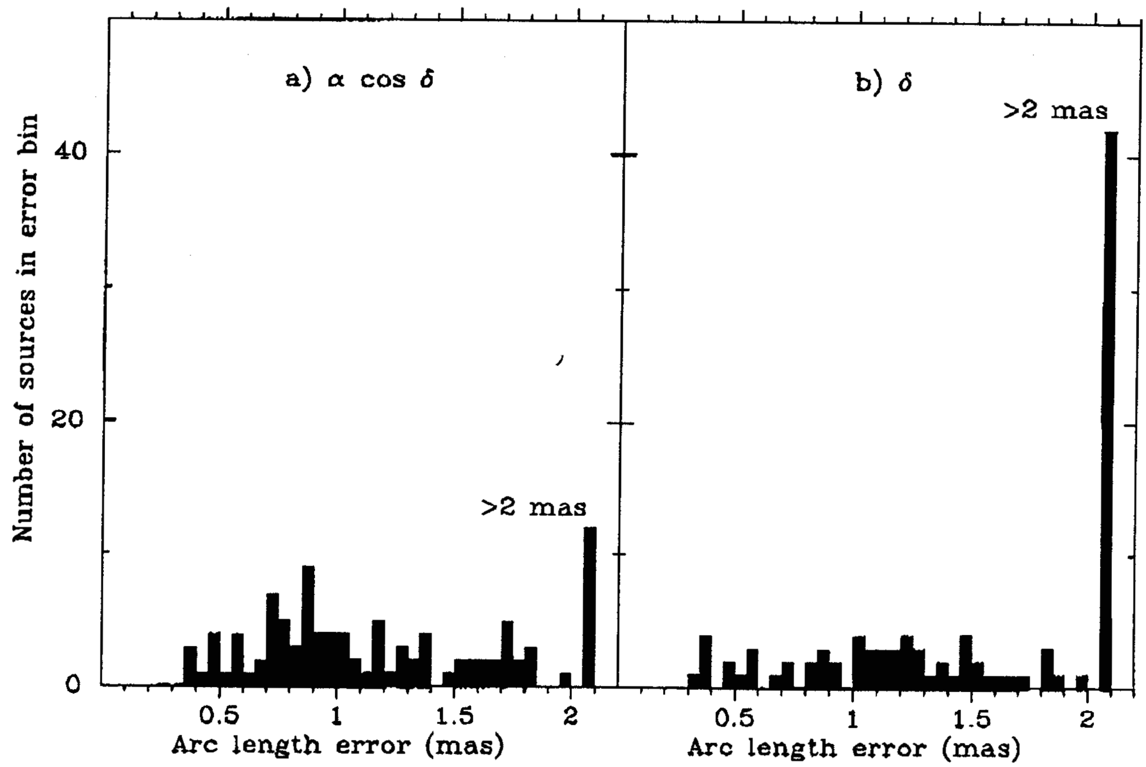

FIG. 8.—Same as Fig. 6, but for "other" sources

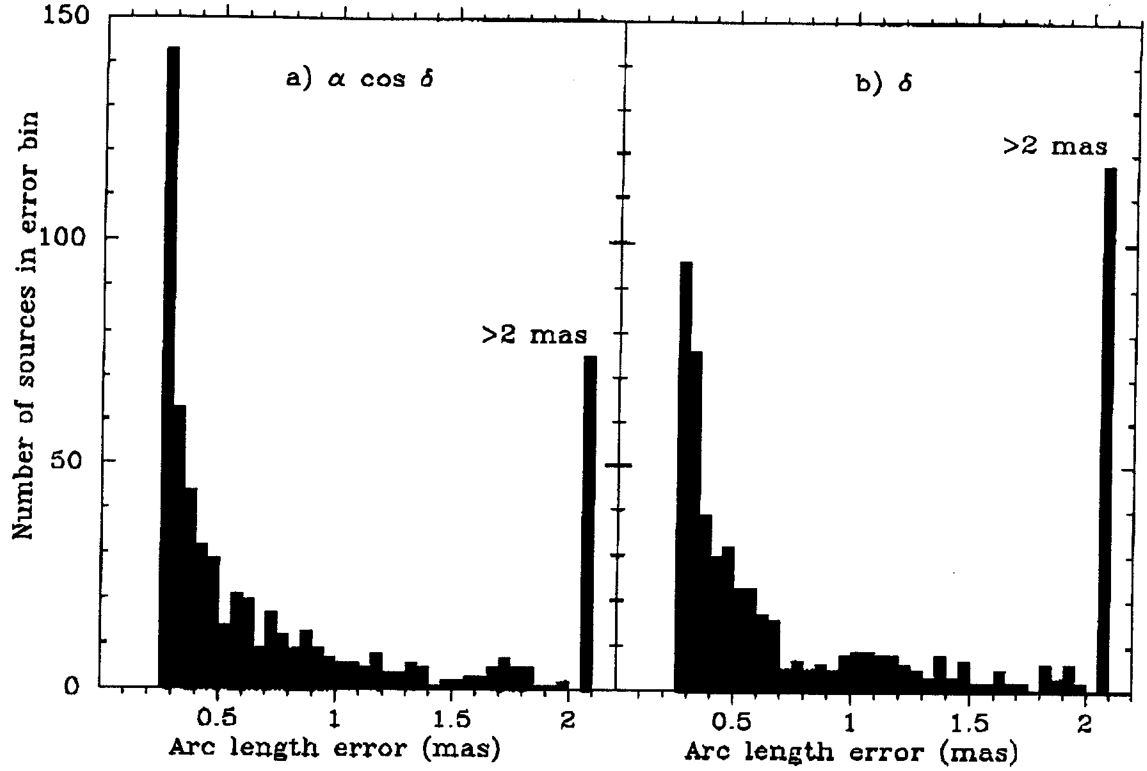

FIG. 9.—Same as Fig. 6, but for all sources

Japan, the ICRF described in this paper replaces the stellar FK5 catalog as the fundamental celestial reference frame as of 1998 January 1. The ICRS (Arias et al. 1995) is adopted as the celestial reference system, and the *Hipparcos* Catalogue (Kovalevsky et al. 1997) is its realization at optical wavelengths. As a consequence, the axes of the celestial reference system are no longer related to the equator or the ecliptic but are maintained from one realization to the nex[t] by the methods described in this paper.

14. EVOLUTION OF THE ICRF

The current realization of the ICRF condenses the infor[-] mation from a particular VLBI data set spanning a define[d] interval of time and reflects a certain state of VLBI analysis

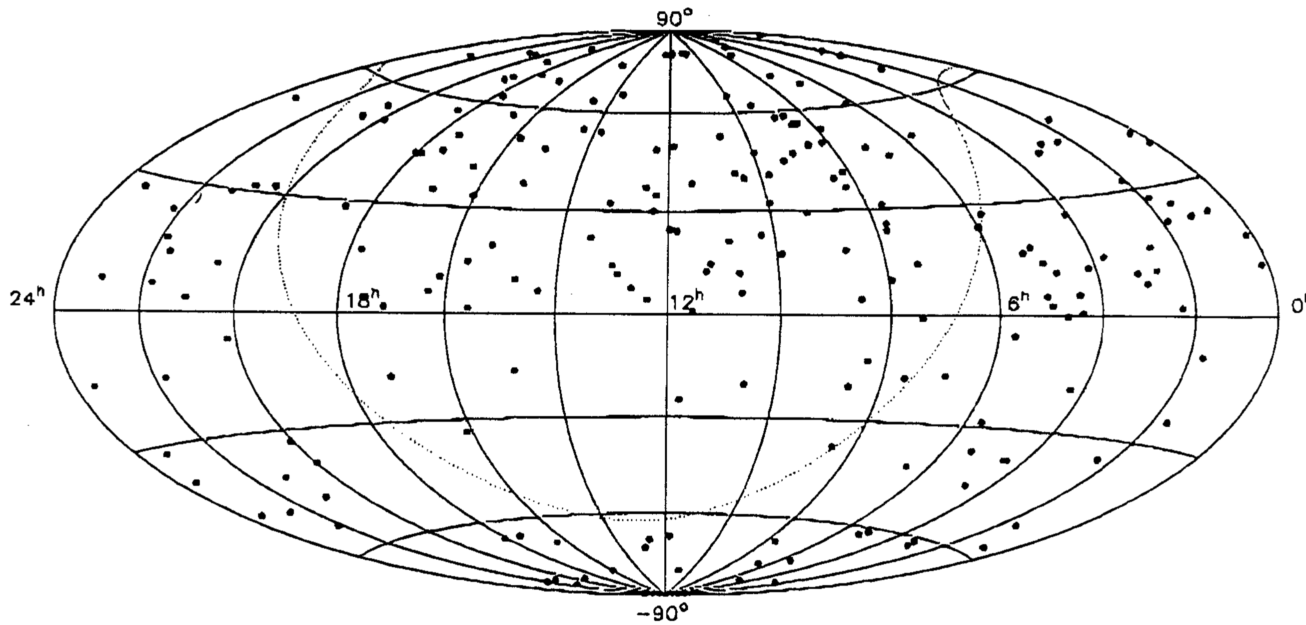

FIG. 10.—Distribution of defining sources on an Aitoff equal-area projection of the celestial sphere. The dotted line represents the Galactic equator

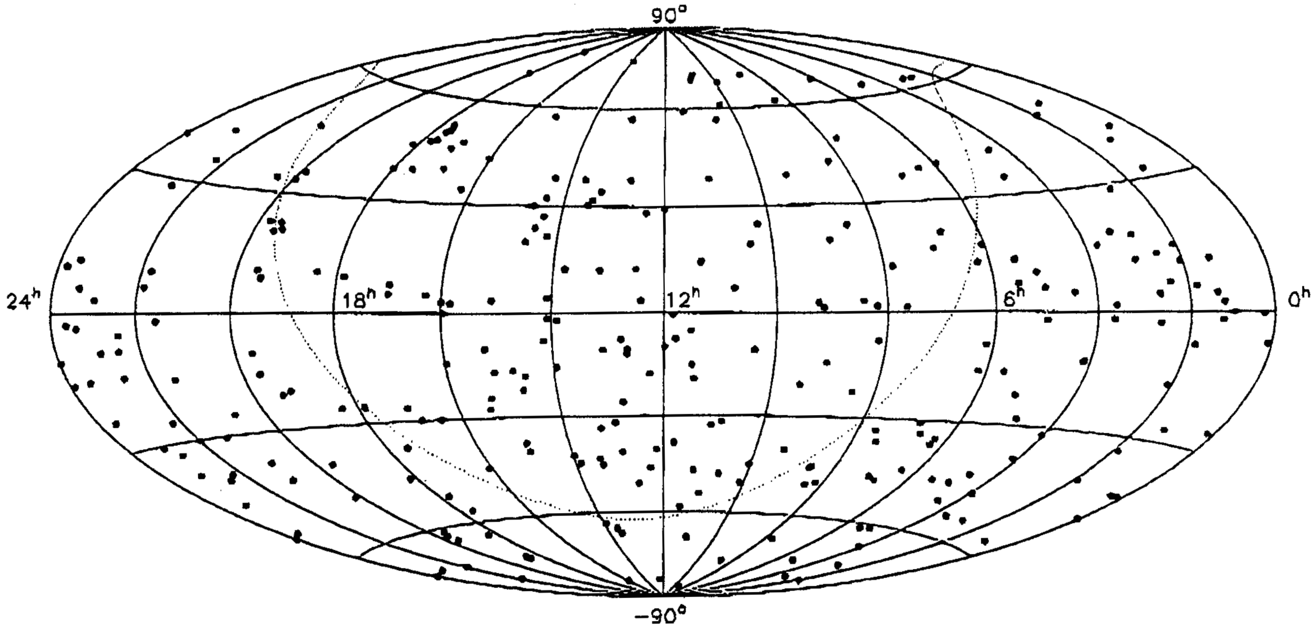

FIG. 11.—Same as Fig. 10, but for candidate sources

As time progresses, we expect the realization of the ICRF to evolve, although changes in the ICRF catalog will be infrequent compared with past practice in VLBI astrometry.

There are several features that distinguish this type of realization from the conventional stellar catalogs that formerly defined the celestial reference frame. First, while we know the positional history of the sources, we cannot predict with absolute certainty what future observations will reveal. The current positions and velocities are a snapshot (or a movie), and continued observations are essential to maintain the viability and integrity of the ICRF. New sources must be observed to replenish and expand the list of candidates, and their positions in the ICRF must be deter mined. Current sources need to be observed periodically t‹ track their behavior. Second, as observations accumulate, i should be possible to move candidate sources up or dowı the scale of usefulness. However, it is conceivable, perhap: even probable, that an identical categorization of source: from an analysis using twice as long a time interval woulc show sources changing categories in unpredictable ways For example, there is no physical reason to expect tha linear position changes can continue indefinitely. Such motion would call into question the fundamental basis o the extragalactic frame, i.e., the great distances of the

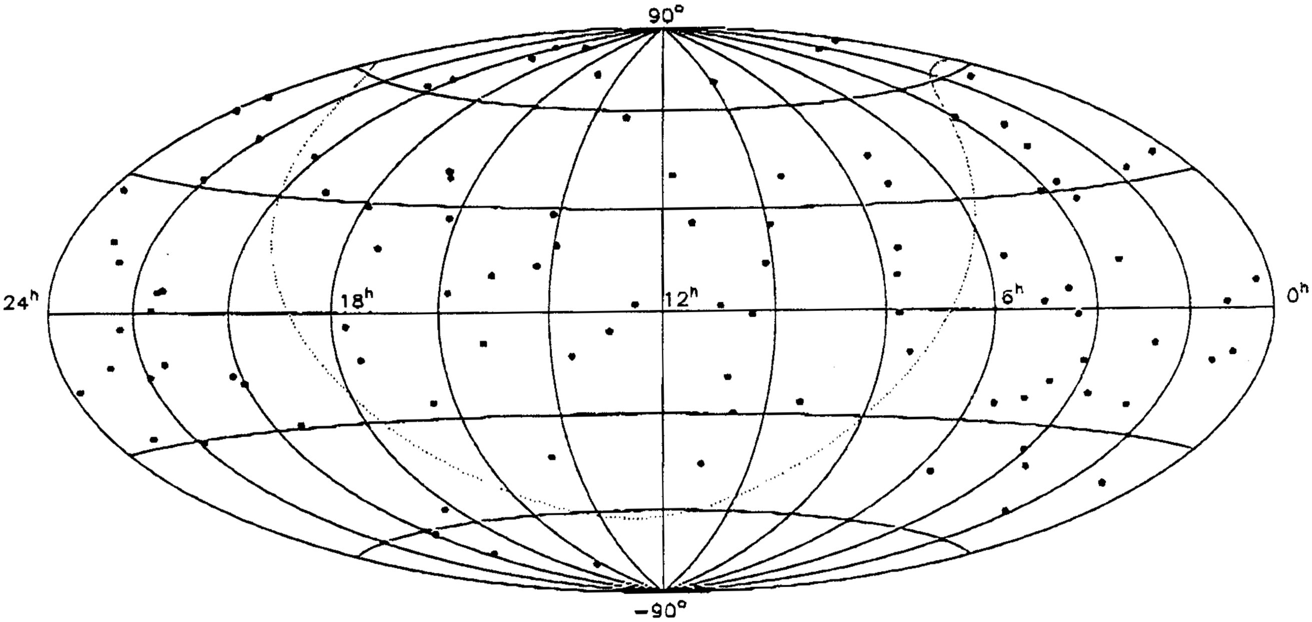

FIG. 12.—Same as Fig. 10, but for "other" sources

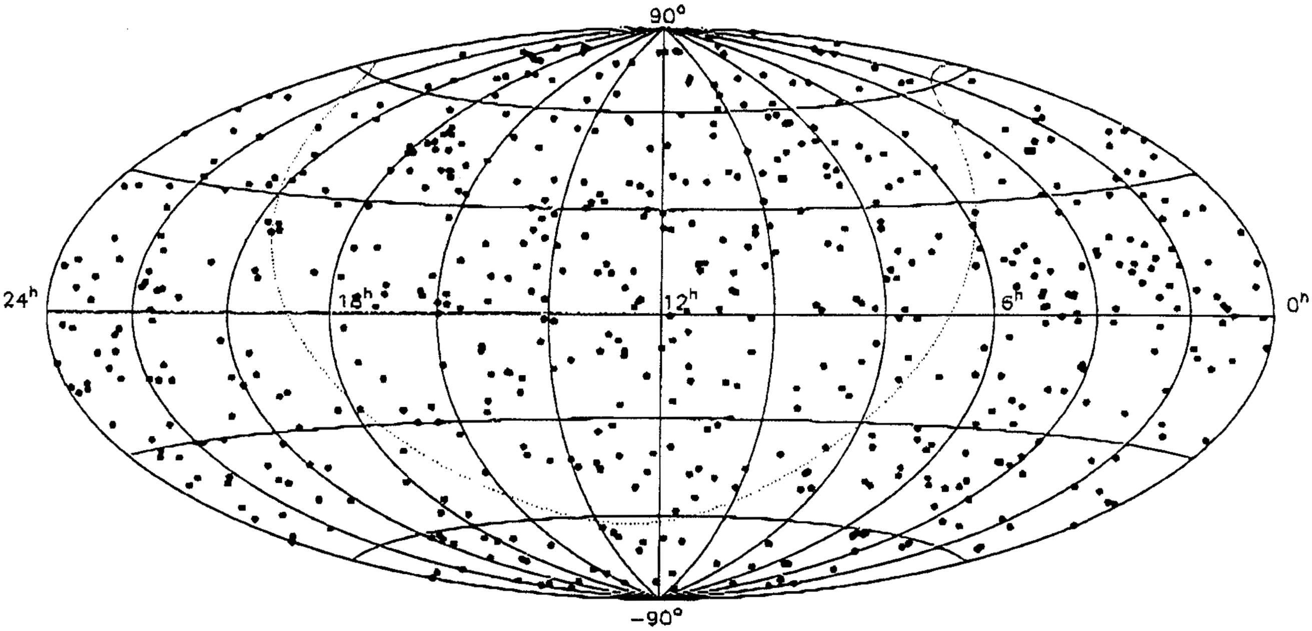

FIG. 13.—Same as Fig. 10, but for all sources

objects. Directed position changes should cease at some time. Conversely, a source now stationary could start apparent motion. Only future experiments and data analysis will show. The problem of position variation may be solved in the future if the application of source structure information permits the identification and use of truly kinematically stable points in the sky. Progress toward this goal has been made in the case of the core-jet source 3C 273 (1226+023). Charlot (1994) has shown that modeling the source structure effects of this source significantly improves the positional stability. This remains to be demonstrated for other sources. Unlike stellar catalogs, however, the original VLBI observations should always be accessible for improved analysis de novo.

Despite the burden of maintenance, the ICRF realized by VLBI astrometry is a great step forward. Compared with stellar realizations, it is intrinsically simpler, much more accurate, more stable, and less susceptible to systemati deformations. It will serve the purposes of astronomy an geophysics well.

VLBI is a collaborative and cooperative activity Without the sustained efforts of many individuals and insti tutions located around the world over an extended perio of time, the new celestial reference frame would not hav been possible. We wish to recognize and thank the designer and fabricators of VLBI instrumentation, from masers t receivers to data acquisition terminals to correlators; th operating personnel at observatories and correlator facili ties; the schedule makers and coordinators; the generation of model builders, software developers, and analysts; an the farsighted visionaries and funding agencies who though the job could be done.

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